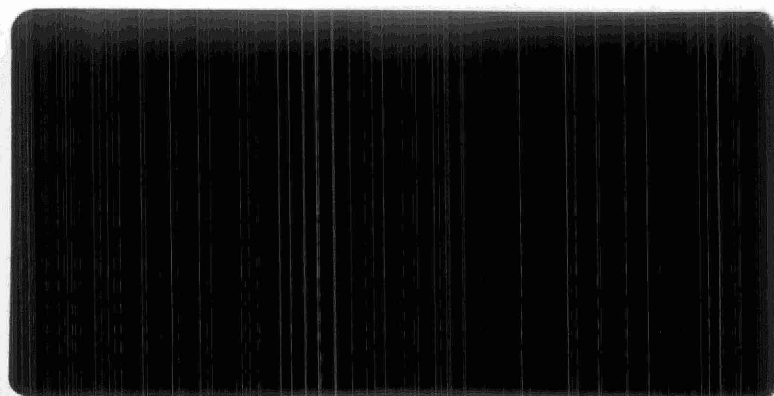


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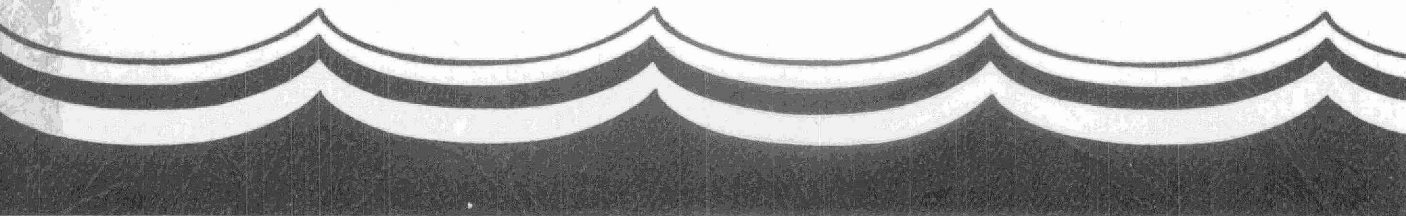


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STRATFORD / AVON RIVER ENVIRONMENTAL MANAGEMENT PROJECT



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Stratford-Avon River Environmental
Management Project

A FEASIBILITY STUDY FOR AUGMENTING
AVON RIVER FLOW BY GROUND WATER

Technical Report No. S-13

Hydrology and Monitoring Section
Water Resources Branch

1982

PREFACE

This report is one of a series of technical reports resulting from work undertaken as part of the Stratford-Avon River Environmental Management Project (S.A.R.E.M.P.).

This two year project was initiated in April 1980, at the request of the City of Stratford. The S.A.R.E.M.P. is funded entirely by the Ontario Ministry of the Environment. The purpose of the project is to provide a comprehensive water quality management strategy for the Avon River basin. In order to accomplish this considerable investigation, monitoring and analysis has taken place. The outcome of these investigations and field demonstrations will be a documented strategy outlining the program and implementation mechanisms most effective in resolving the water quality problems now facing residents of the basin. The project is assessing urban, rural and in-stream management mechanisms for improving water quality.

This report results directly from the aforementioned investigations. It is meant to be technical in nature and not a statement of policy or program direction. Observations and conclusions are those of the authors and do not necessarily reflect the attitudes or philosophy of all agencies and individuals affiliated with the project. In certain cases, the results presented are interim in nature and should not be taken as definitive until such time as additional support data is collected.

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ABSTRACT

This report considers the feasibility of using ground water to augment stream flow in the Avon River. A review of existing well records and geologic maps of bedrock and overburden was undertaken. Ground-water chemistry was assessed by a sampling and analysis program for area wells.

Results show that sufficient quantities of water might be available from bedrock sources near the river to provide for augmentation of 1 to 3 cfs. Pilot studies to identify well sites and assess well yields and interference problems would be required as part of further studies. As a cost reducing measure, the possibility of augmentation from Stratford city wells could be explored.

Based on ground-water and stream-water chemistry, the use of ground water for flow augmentation would serve to dilute most water quality constituents thus improving water quality.

(Work undertaken subsequent to the completion of this report indicates that an acceptable level of dilution for phosphorus would require in excess of 25 cfs or 9,000 gpm of augmentation, compared to the 1 to 3 cfs considered necessary at the time of the study documented in this report. In view of the much larger amounts of water now considered necessary, it is considered unlikely that bedrock aquifers in the study area could practically provide this level of augmentation.)

All data and results in this report, except those relating to water quality, are in English units because all the background hydrogeologic data derived from such sources as relevant topographic maps, water well records, etc., are available only in English units. Conversions of data from these sources to metric units proved to be too cumbersome. However, if conversions from English to metric units are necessary, the following factors can be used.

Metric Conversions

feet x 0.305	= metres
miles x 1.609	= kilometres
square miles x 2.590	= square kilometers
cubic feet/second (cfs) x 28.316	= litres/second
(Imperial) gallons x 4.546	= litres
(Imperial) gallons/minute x 0.0758	= litres/second

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1. INTRODUCTION

This investigation focuses on determining the feasibility of using ground water to augment flows in the Avon River by about 1 to 3 cfs (374-1122 gallons per minute). This augmentation would provide additional water during low flows for the assimilation of waste discharged from the Stratford sewage treatment plant (STP), and might help to reduce nutrient concentrations in the stream to discourage the growth of aquatic plants.

The primary area of study for ground-water augmentation extends about 2 miles on both sides of the Avon River between the City of Stratford and the confluence of the Thames River, a distance of approximately 10 miles in length. It was assumed that no separate supplies of ground water were available for augmentation within the City of Stratford in order to ensure adequate future supplies for the city. A secondary area under possible consideration for flow augmentation extends upstream for about 3 miles from Stratford city limits. Although this area appears likely to contain sufficient ground water, flows in this portion of the Avon River are non-existent at certain times of the year and flow augmentation would not be physically feasible during these times. Hydrogeologic data are presented in Appendix A for this area but are not dealt with in this report.

For economic and practical reasons, the target for the development of ground water for flow augmentation is limited to adjacent lands on both sides of the Avon River extending from the sewage treatment plant to about Avonton, a distance of approximately four miles.

Water-well record data were used to determine the availability of ground water, supported by geologic maps of bedrock and overburden and related background data shown in the Thames River ground-water report (Goff, Brown, 1981). In addition, field work involved checking the surficial geology of the river banks and surrounding areas, and water samples were taken from selected wells for inorganic chemical analyses.

The surficial geology of the study area (Figure 1) consists primarily of lacustrine silt and clay, and sandy silt till with thin deposits of gravel, sand and silt along the length of the river. The overburden thickness in the area ranges from about 50 to 170 feet (Figure 2).

The bedrock consists mainly of grey and brown limestones of the Dundee, Lucas, and Amherstburg formations (Figure 3). The bedrock surface slopes in an irregular manner generally in an east-west direction and is characterized by a valley located south of the Avon River and running approximately parallel to it (Figure 4).

In the past study of ground water in the Thames River basin (Goff, Brown, 1981), bedrock aquifers were shown to be important in the Avon River basin where the current feasibility study is situated. In this area the limestones are exploited for large quantities of good-quality ground water and site-specific development of ground water for augmentation will likely depend on locating these sources adjacent to the Avon River.

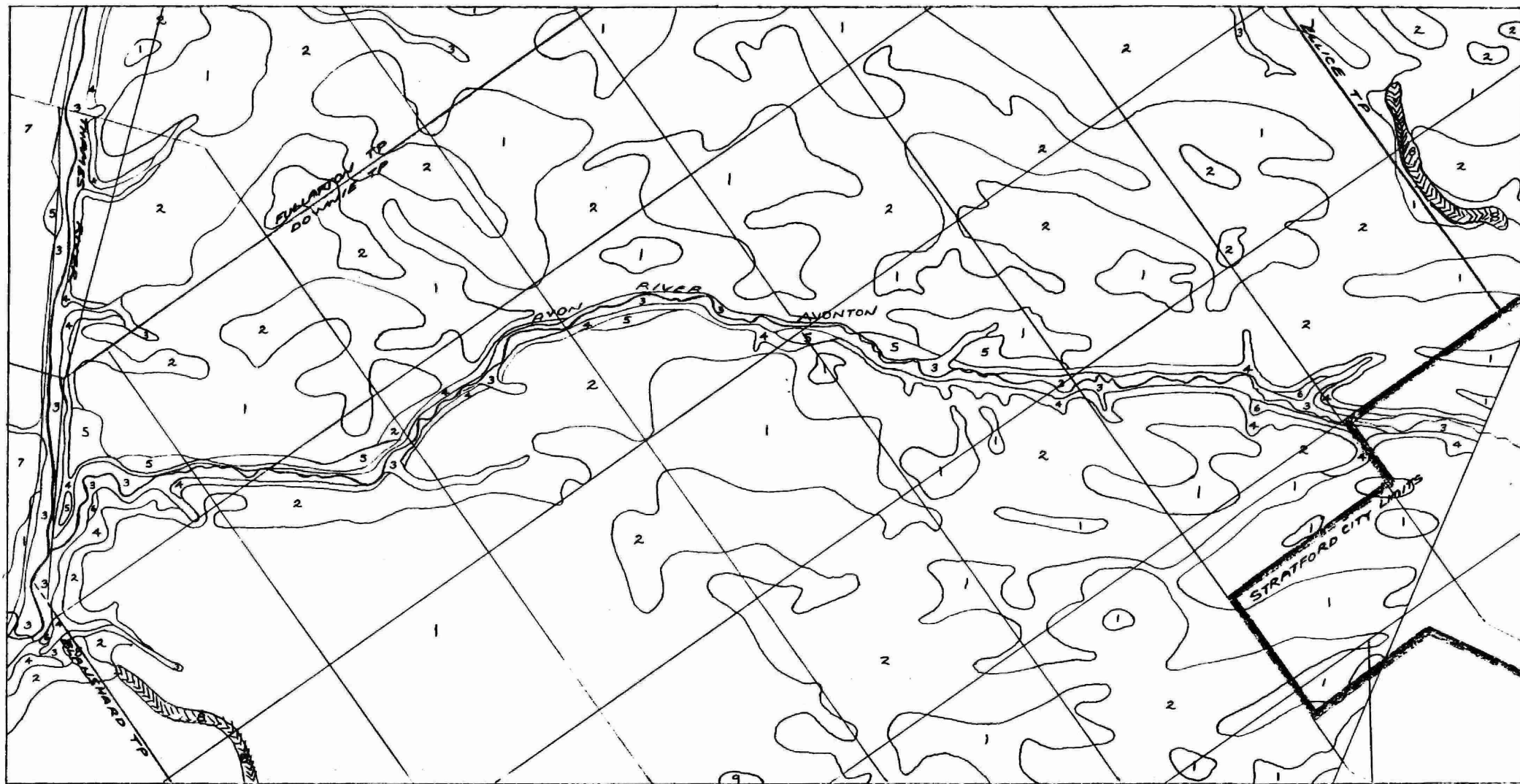


Figure 1. Surficial geology

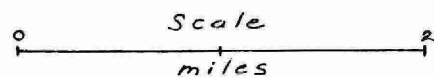


FIGURE 1: SURFICIAL GEOLOGY

Legend:

- | | |
|---|--|
| 1 | Lacustrine silt and clay |
| 2 | Stratford till clay till |
| 3 | Alluvium: stream deposits of gravel, sand and silt |
| 4 | Tavistock till: sandy silt till |
| 5 | Outwash gravel |
| 6 | Catfish Creek till: stoney, sandy to silty till |
| 7 | Rannoch till: clayey to silty till |
| 8 | Ice contact gravel; esker |
| 9 | Ice contact sand |

NOTE: sequence of numbers does not designate age of deposits

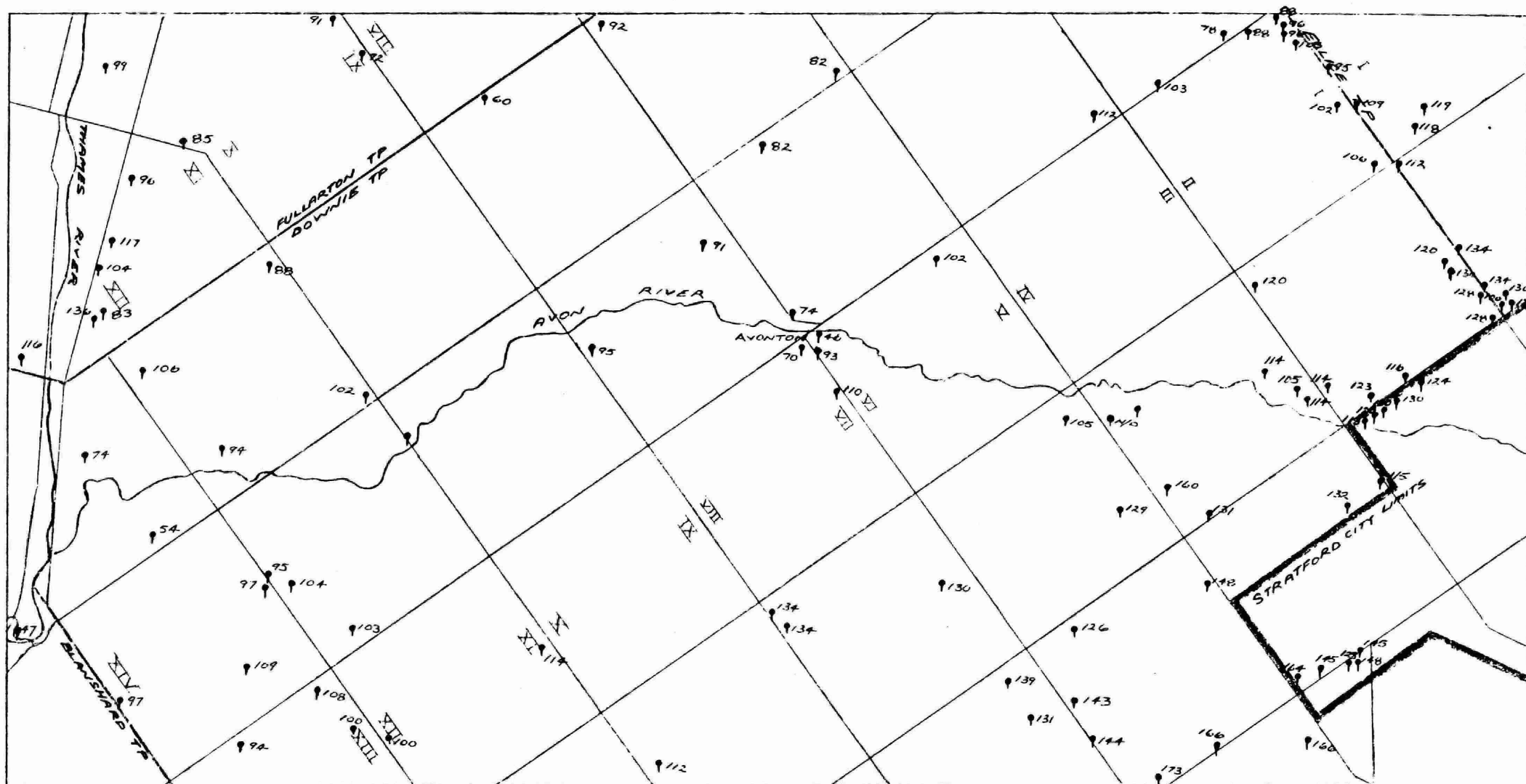


Figure 2. Depths to bedrock

Scale
0 miles 2

91 overburden thickness (feet)

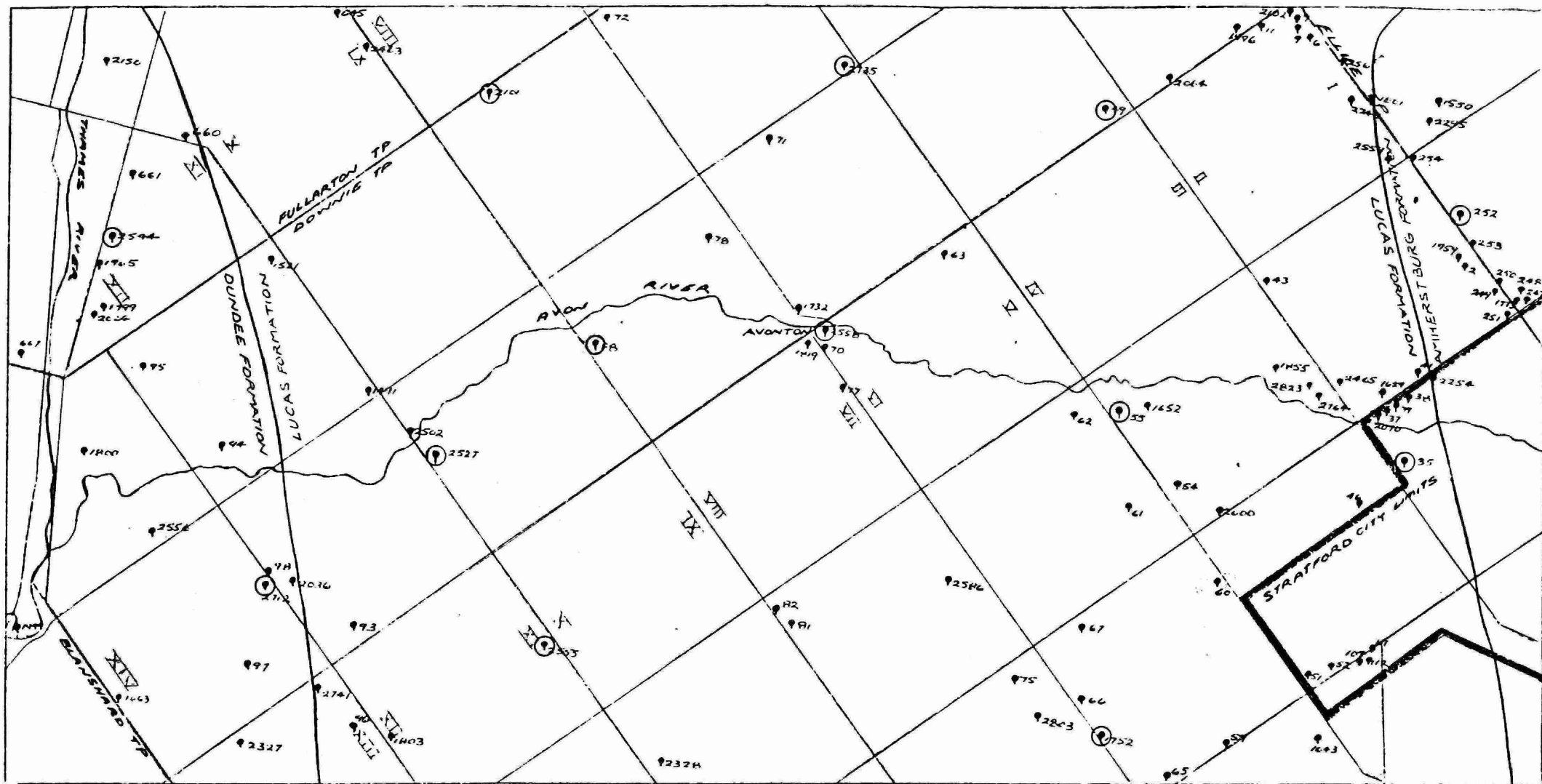


Figure 3. Bedrock geology and aquifers

Scale
0 1 2
miles

95 well location and number
88 sampled bedrock well for water quality analysis

Dundee Formation: Upper Member: medium brown limestone
Lower member: light brown limestone containing quartz sand and chert

Lucas Formation: Anderdon Member: brown limestone

Amherstburg Formation: Gray to dark brown limestone and dolomite, locally cherty, bituminous and biostromal

2. HYDROGEOLOGY AND GROUND-WATER AVAILABILITY

Bedrock formations contain the main water-bearing zones in the area, with only a small number of wells ending in sand and gravel formations in the overburden. The locations of known bedrock wells are shown on Figure 5. Due to the density of bedrock wells northwest of Stratford, only representative wells are shown in this area. Overburden wells for which records are on file with the MOE are plotted on Figure 6.

The main bedrock aquifers in the area are located in the Dundee, Lucas, and Amherstburg formations. The depths to water in bedrock wells range from 80 to 255 feet, with the majority of wells finding water at about 150 feet from the surface (Figure 5). Most wells find adequate (domestic) amounts of water within 50 feet below the bedrock surface. The piezometric surface in bedrock indicates a regional movement of ground water towards the Thames River, with a local deflection of ground water towards the Avon River (Figure 7).

Ground-water yields from bedrock are variable, but indications are that there is a potential for large capacity wells next to the Avon River (Figure 8). By way of example, the City of Stratford municipal wells obtain water from similar bedrock formations and well yields as high as 1000 gpm are on record.

There are only a few wells that end in overburden and the aquifers shown in Figure 9 are mainly shallow (less than 50 feet deep) sand and gravel formations yielding limited amounts of water (Figure 10). The narrow aquifers along the Thames and Avon rivers are thin floodplain sands and gravels at the surface and do not constitute a potential for obtaining large quantities of ground water. Although it is conceivable that some portions of the buried sand and gravel formations may yield larger quantities of water, the effort to find large capacity wells in overburden is questionable since bedrock is known to yield large amounts of water.

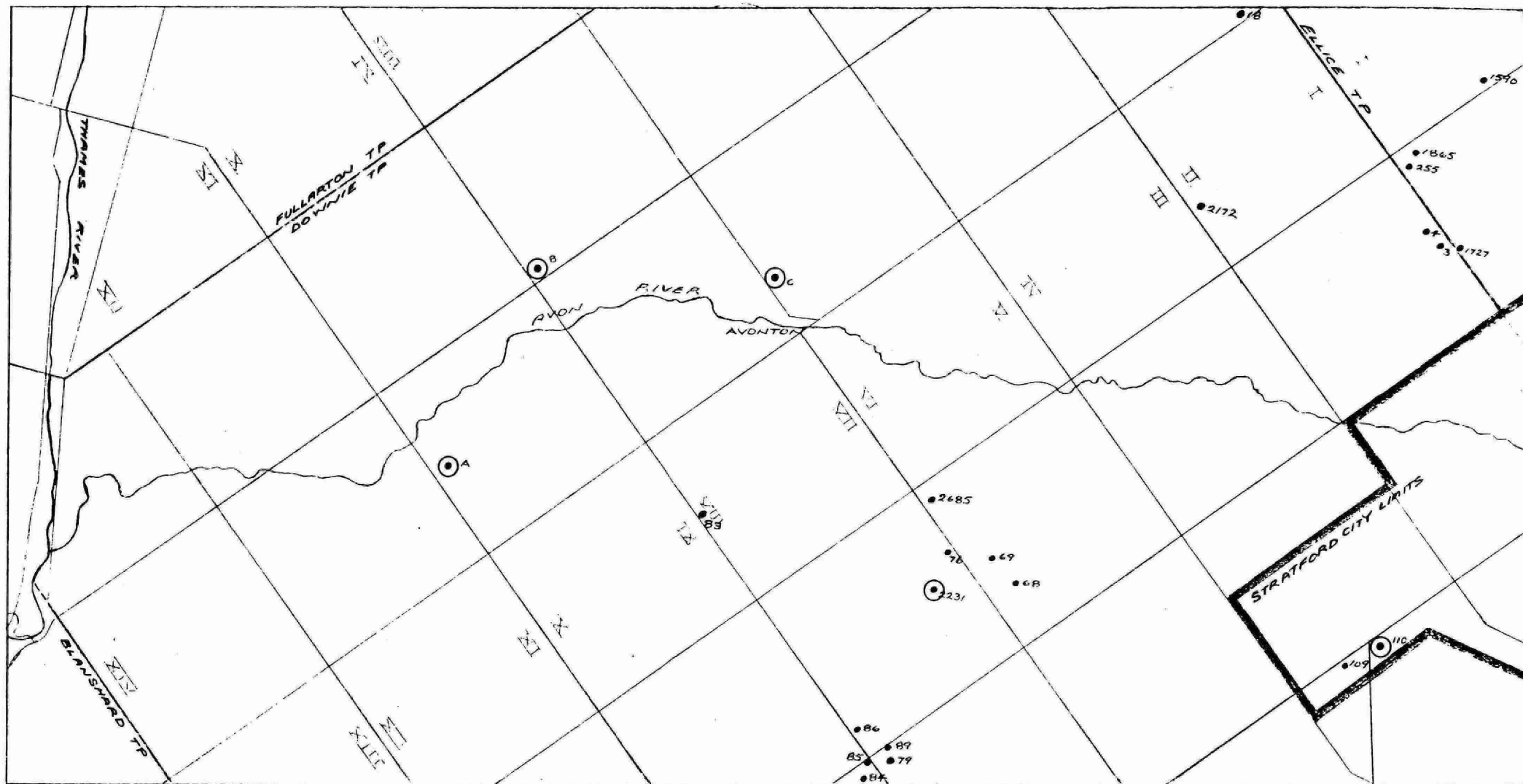


Figure 6. Overburden wells

Scale
0 ————— 2
miles

- 83 well location and number
- sampled overburden well for water quality analysis

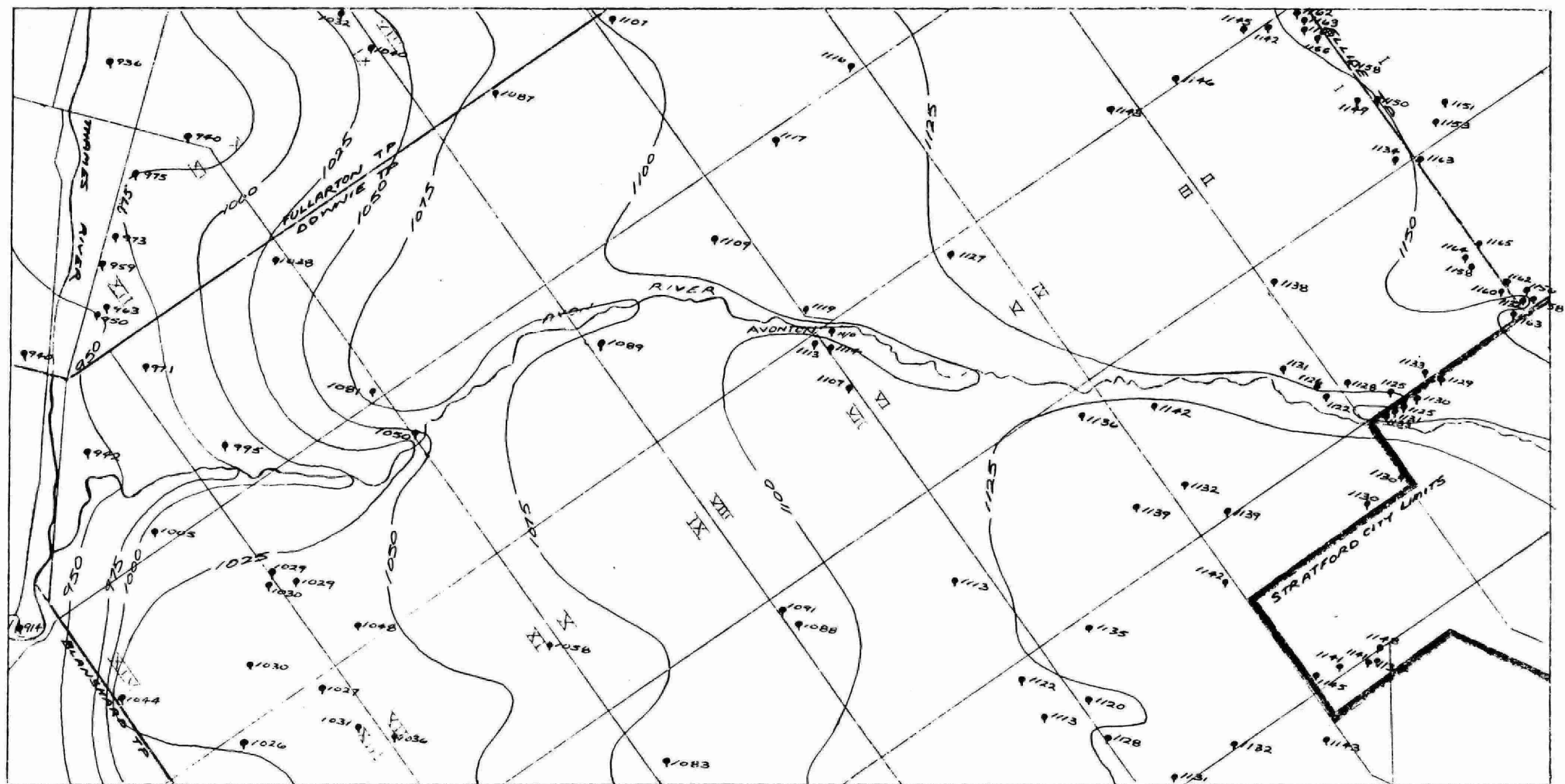


Figure 7. Piezometric surface in bedrock

Scale
0 1 2
miles

971 static level elevation in bedrock well (feet)
1000 piezometric elevation contour

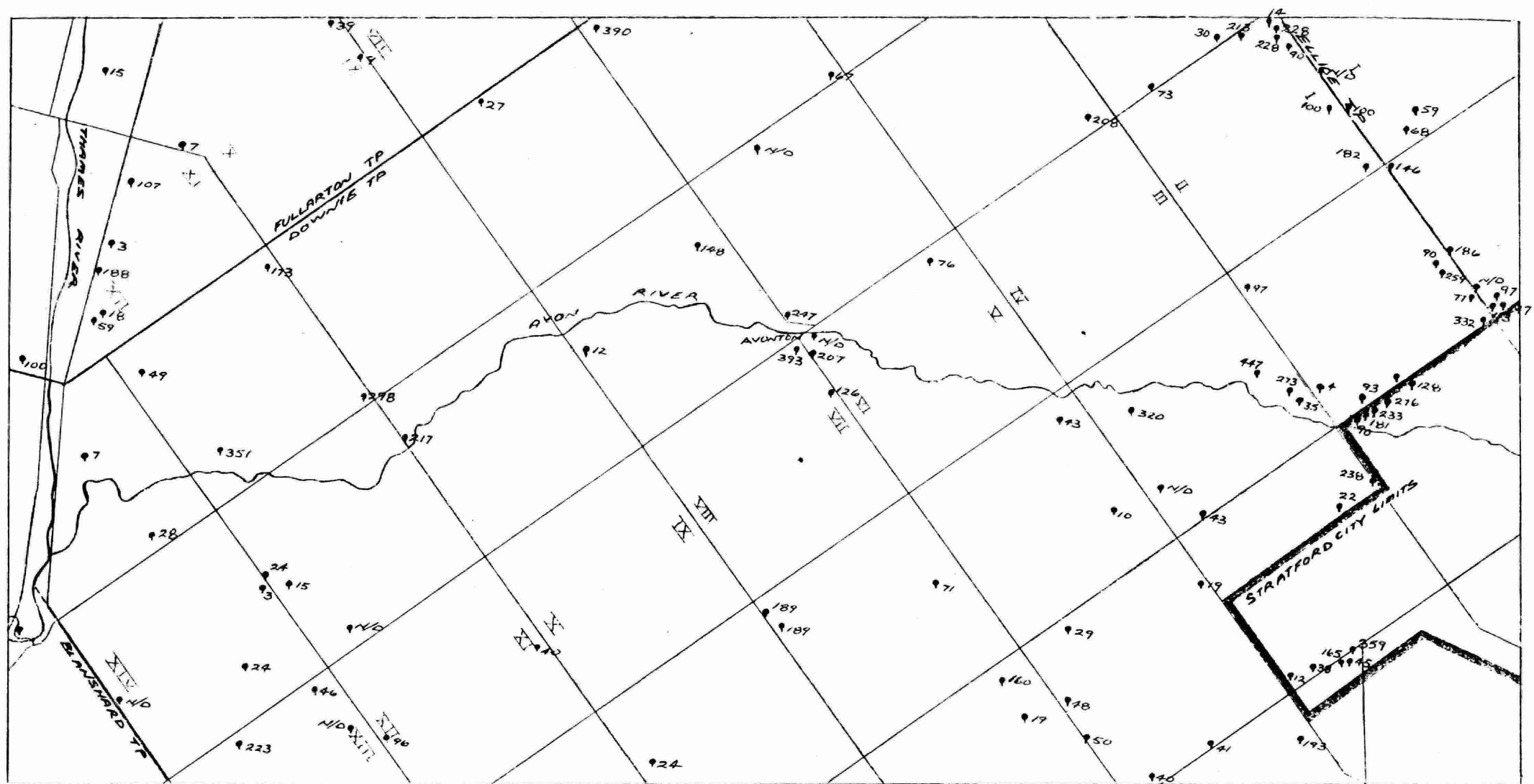


Figure 8. Theoretic yields of bedrock wells

Scale
0 ————— 2
miles

● 40 theoretic yield (gpm.)

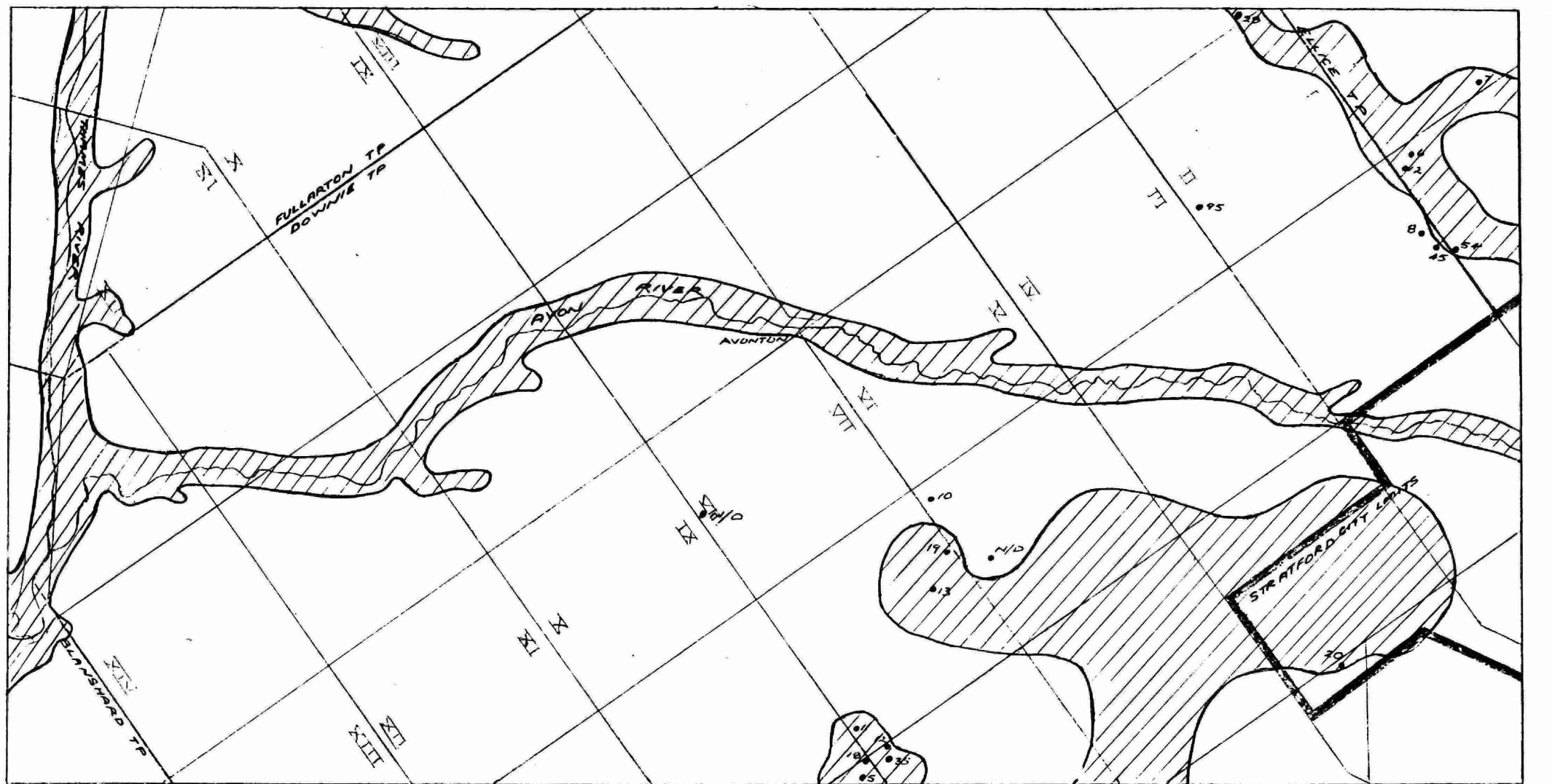
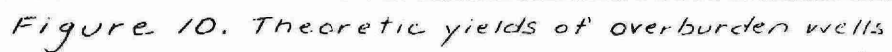


Figure 9. Extent of shallow overburden aquifers

Scale
0 2
miles

extent of shallow aquifer: sand and/or gravel
•18 depth water found in overburden (feet)



A horizontal number line with tick marks at 0, 1, and 2. The word "scale" is written above the line, and "miles" is written below the line.

• 5 theoretic yield (g.p.m)

As with ground-water movement in the bedrock, regional, shallow movement in the overburden is towards the Thames River, with a strong local component of ground-water flow towards the Avon River. This is shown by the water table configuration in Figure 11. It indicates that the Avon River is receiving shallow ground water, although the amount of water is probably small because the shallow overburden materials are poorly permeable. Because the water table elevation throughout the study area is higher than the piezometric surface in bedrock, there can be no flowing wells in this part of the Avon River basin.

The occurrence of sand and gravel aquifers in the overburden, and the locations at which water is found in bedrock, are shown in five geologic cross-sections in Appendix B.

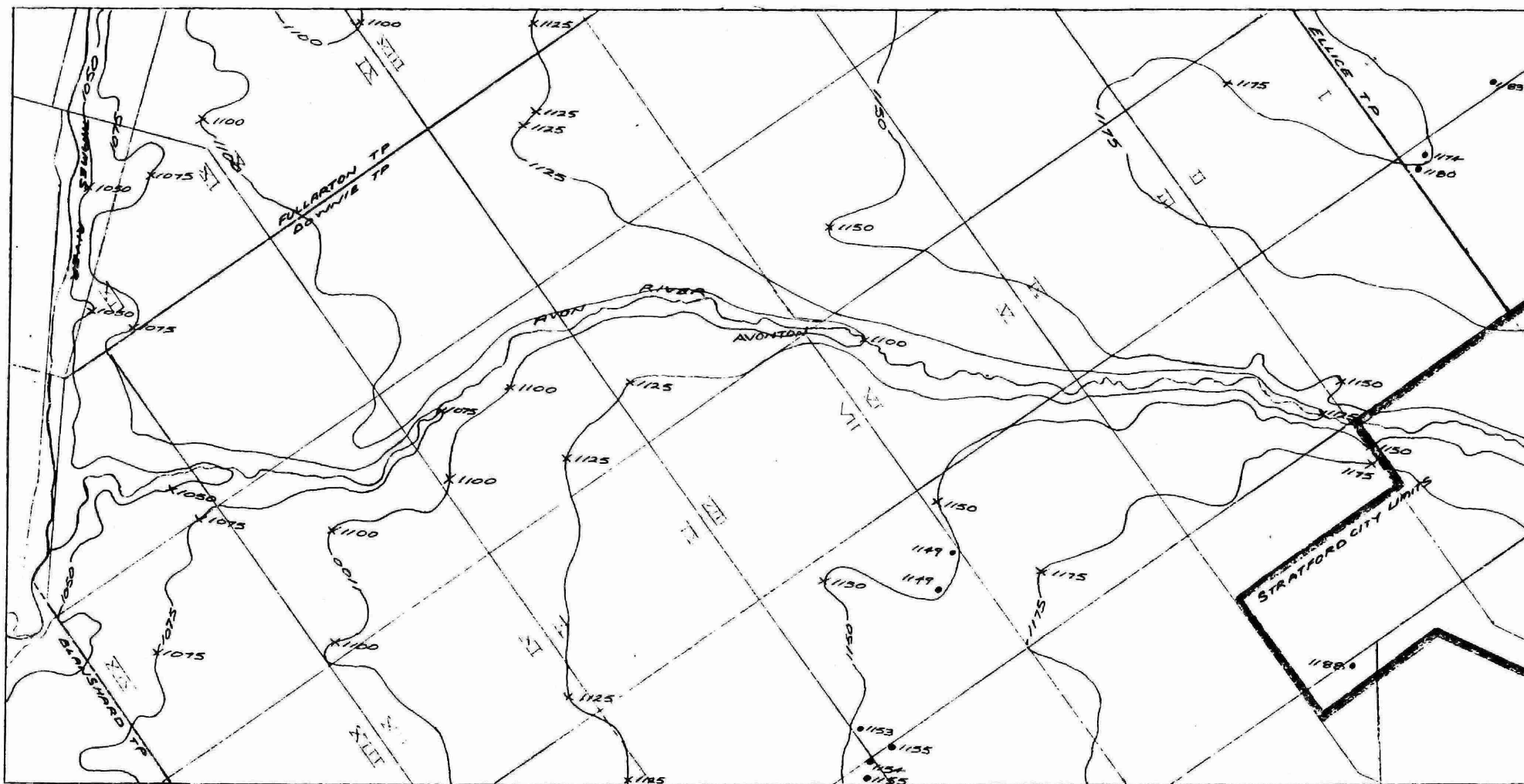


Figure 11. Water table configuration

Scale
0 ————— 2
miles

- 1084 static level elevation in shallow well (feet)
- 1000- water table elevation contour (feet)
- x1150 water table elevation in the stream (feet)

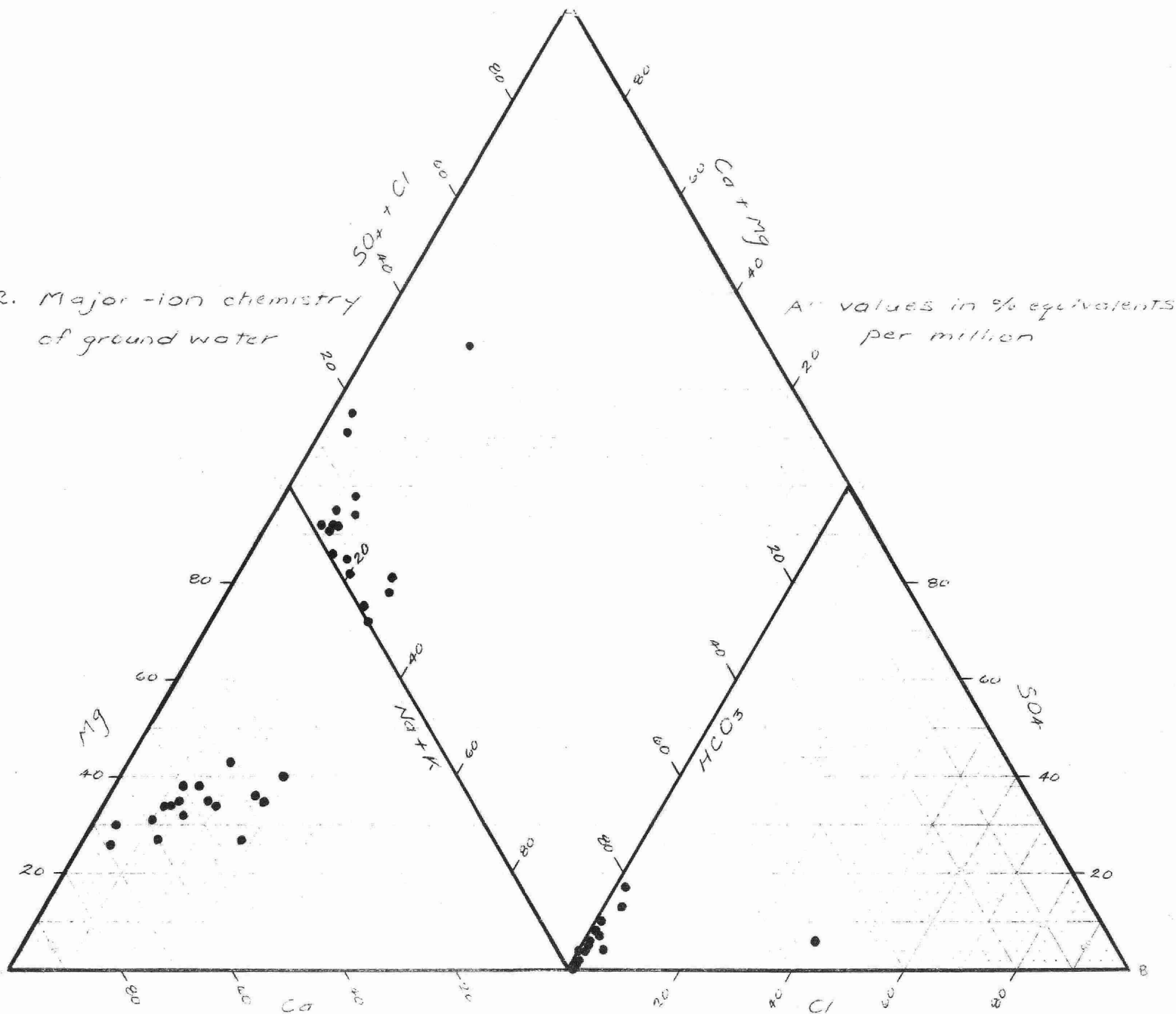
3. HYDROCHEMISTRY

Ground-water samples taken from selected bedrock and overburden wells were analyzed for the common inorganic parameters to ensure compatibility with surface-water quality. Thirteen samples were taken from bedrock wells and five samples were obtained from overburden wells. Their locations are shown on Figures 3 and 6. The results are plotted on Figure 12 to indicate the overall quality of these waters; their individual analyses are shown in Table 1. Most wells on Figure 12 indicate a predominance of Ca and HCO_3 typical of ground waters in overburden and bedrock in this area.

Water quality data recorded from January to August 1981 from nine sampling stations in the Avon River (Appendix C) show that five surface-water quality parameters can be compared to well samples gathered in the area: pH, chloride, nitrate, total phosphorus and specific conductance. Summary statistics are given in Table 2 for comparison. Ground-water pH results average 7.75 with generally higher levels for stream water. Levels of chloride in the river range from as high as 210 mg/L below the discharge point of the STP to as low as 20 mg/L at the confluence of the Thames River at Station 13; this compares with an average of 2.0 mg/L from bedrock well samples and 0.5 from overburden wells, omitting the anomalously high value of 155 mg/L in well 110. The high value is probably indicative of contamination and not representative of natural ground-water conditions in the area.

Samples from 14 of the 18 wells recorded nitrate levels of less than 0.01 mg/L, with the highest value of 5.53 mg/L. Nitrate levels in the stream vary widely, with most ranging between 4 and 10 mg/L. The amount of total phosphorus recorded in surface waters was, with some exceptions, under 0.5 mg/L. Generally low levels of total phosphorus were recorded in the well samples, with the exception of one high reading of .166 mg/L. The reason for this high reading is not known, but it is considered not indicative of the phosphorus levels in ground water in the area. The mean total phosphorus concentration in bedrock wells, omitting this observation is 0.025 mg/l.

Figure 12. Major-ion chemistry of ground water



Based on these cursory comparisons, in-stream mixing of ground and surface waters should be compatible and in most instances ground water discharged into the Avon River should improve inorganic chemical quality of the river. The degree of improvement will vary with location in the river and augmentation rate. Analysis completed after the writing of this report indicates an augmentation requirement of at least 25 cfs. This analysis is documented as an addendum in Appendix D.

TABLE 1. WATER QUALITY RESULTS OF SAMPLED WELLS

					MDE	Constituents in Milligrams per Litre																		
					Well	Owner's															Tot	Tot	Temp	Sp
No.	Location				No.	Name	pH	Fe	Ca	Mg	Na	K	SO ₄	CL	NO ₃	TP	FRP	Alk	Hard	°C	Cond			
<u>September 21, 1981</u>																								
1	Con	1 Lot	8	252	Tziavaras, T.	7.77	0.40	50.5	14.0	12.0	1.05	7.0	2.0	0.01	0.008	0.004	203	184	10	382				
2	Con	3 Lot	16	49	Boyes, E.	7.61	5.10	69.0	22.4	13.0	1.10	3.0	1.0	0.01	0.024	0.002	242	265	14	520				
3	Con	5 Lot	21	2735	Gotts, R.	7.70	1.32	51.5	19.8	12.2	0.95	6.0	1.0	0.01	0.050	0.008	233	210	9	425				
<u>September 22, 1981</u>																								
4	Con	8 Lot	25	2101	Meinen, B.	7.69	0.48	28.0	22.2	29.5	1.10	11.0	1.0	0.03	0.028	0.016	217	161	11	410				
5	Con	18 Lot	28	1965	Baird, L.	7.54	1.31	84.5	20.0	6.4	0.55	38.0	7.5	0.01	0.031	0.003	264	294	11	560				
6	Con	13 Lot	18	2712	Ready, C.	7.82	0.54	40.5	18.6	17.3	0.90	5.0	1.5	0.02	0.021	0.012	215	178	10	395				
7	Con	10 Lot	19	90	Campbell, D.	7.80	1.06	49.5	23.6	18.5	0.90	19.0	3.0	0.01	0.166	0.033	245	221	10	477				
8	Con	10 Lot	18	A*	Hotson, J.	7.80	0.86	50.0	23.0	13.8	0.90	9.0	0.5	0.01	0.026	0.009	247	220	10	452				
9	985 Erie St.			110	Saville, R.	7.72	0.58	84.0	56.0	38.0	7.00	28.5	155	0.38	0.027	0.008	287	441	12	1040				
10	Con	11 Lot	13	2555	Riley, J.	7.92	0.80	50.5	19.0	11.2	0.80	10.0	2.0	0.01	0.014	0.007	218	205	9	415				
11	Con	8 Lot	19	2527	Hotson, M.	7.62	0.08	84.0	23.0	5.2	0.15	33.5	4.5	5.53	0.004	0.004	266	305	10	570				
12	Con	8 Lot	21	B*	Stevenson, J.	7.87	0.86	32.5	18.4	27.5	0.95	18.0	0.5	0.01	0.023	0.007	206	157	8	406				
13A	Con	6 Lot	17	C*	Hay, B.	7.69	0.04	52.5	20.8	15.6	0.95	26.0	0.5	0.01	0.034	0.009	236	217	10	471				
13B	Con	6 Lot	15	2558	Aitcheson, M.	7.82	0.24	37.0	21.8	27.5	0.95	5.0	1.0	0.01	0.032	0.022	228	182	7	413				
15	Con	7 Lot	8	2231	Farquhar, A.	7.86	0.67	39.0	17.2	18.4	1.00	2.5	0.5	0.01	0.026	0.016	210	168	11	377				
16	Con	6 Lot	3	1752	Dill, R.	7.79	0.45	42.0	15.0	29.0	1.00	2.0	0.5	0.01	0.016	0.012	218	167	8	393				
17	Con	4 Lot	9	55	Williams, W.	7.75	2.00	47.0	17.6	14.0	0.95	5.0	0.5	0.01	0.036	0.007	222	140	10	401				
18	444 Lorne Ave.			35	Switzer, P.	7.86	0.50	30.5	13.4	37.0	1.15	4.0	1.0	0.01	0.041	0.029	212	131	9	389				

*M.O.E. well number not available for this well.

Fe = Iron K = Potassium Alk = Total Alkalinity
 Ca = Calcium SO₄ = Sulphate TP = Total Phosphorus
 Mg = Magnesium Cl = Chloride FRP = Filtered Reactive Phosphorus
 Na = Sodium NO₃ = Nitrate Hard. = Total Hardness as CaCO₃

Temp. = Temperature
 Sp. Cond. = Specific Conductance at 25 °C

TABLE 2: COMPARISON OF GROUND-WATER AND STREAM-WATER
CHEMISTRY - 1981^{*}

SAMPLE DESCRIPTION		TP	WATER QUALITY PARAMETER ^{**}			Sp Cond
			NO ₃	Cl ⁻	pH	
13 bedrock well samples	mean	0.036	0.44	2.0	7.74	442
	max	0.166	5.53	7.5	7.92	570
	min	0.004	0.01	0.5	7.54	382
4 overburden well samples (well #10 omitted)	mean	0.027	0.01	0.5	7.80	427
	max	0.034	0.01	0.5	7.87	471
	min	0.023	0.01	0.5	7.69	377
Stream-water at: Station 7	mean	0.41	5.36	90.6	7.80	958
	max	1.35	10.30	148.0	8.20	1270
	min	0.07	0.71	34.0	7.44	530
Station 9	mean	0.23	5.55	76.0	8.09	862
	max	0.67	8.00	130.0	8.50	1170
	min	0.08	4.13	26.0	7.72	490
Station 11	mean	0.17	5.14	73.8	8.17	863
	max	0.45	6.90	148.0	8.61	1160
	min	0.06	2.67	20.5	7.73	570
Station 13	mean	0.18	5.23	88.2	8.18	851
	max	0.36	7.40	210.0	8.94	1140
	min	0.06	1.23	20.0	7.56	464

* Source of Stream data: Water Quality Monitoring Results
for the Avon River - 1981, Technical
Report no. S-3, Stratford/Avon River
Environmental Management Study.

** TP = Total Phosphorus (mg/L P); NO₃ = Nitrate (mg/L N);
Cl⁻ = Chloride (mg/L); Sp. Cond. = Specific Conductance
(umhos/cm²)

4. POSSIBLE ENVIRONMENTAL EFFECTS

The development of high capacity wells adjacent to the Avon River may cause interference with nearby domestic wells and also reduce the discharge of shallow ground water locally in the stream. The ultimate location and design of the augmentation wells would have to take these possibilities into account and existing MOE policies on interference through the Permit To Take Water program would apply. Any wells that are designed to pump more than 50,000 litres per day will require a Permit To Take Water from the MOE, and site-specific data on possible interference will be evaluated prior to issuing a Permit.

Because the wells are to be pumped periodically and presumably for only short periods during low flows, interference is not expected to be a major constraint to an augmentation project.

5. RECOMMENDATIONS

As a next step in the augmentation project, a pilot study using available City of Stratford (untreated) ground-water supplies should be considered. The pilot study should be run at various augmentation rates to determine the possible effects of augmentation on river water at various points in the river. This would indicate whether expected improvements in river water quality are possible, and the amount and quality of ground water necessary for these improvements.

Assuming the pilot study is successful in improving river water quality to the desired degree, the use of ground water from the city supplies should be investigated. The use of existing ground water from city supplies would reduce the ultimate cost of the augmentation project considerably and be most practical in a situation where the capital project costs can be high and may not be justified if intermittent augmentation during low flows only is anticipated. Buying of city water at a reduced cost below the cost of developing and maintaining separate ground-water supplies may be a viable option.

If and when separate ground-water wells are required for flow augmentation, and after some form of pilot study has proven to be successful, test drilling should be carried out. Potential test drilling sites should be located as close to the river as possible and generally between Stratford and Avonton. Road allowances may be used where possible. Test drilling should be conducted into bedrock to locate suitable quantities of water, followed by appropriate pumping tests to determine the amount of water available, its quality as pumping progresses, and the potential cone of interference around the test wells. Assuming that the pilot study has shown a flow augmentation of 1-3 cfs (374-1122 gpm) to be adequate, up to about three separate supply wells might be needed to obtain the required quantity. The test drilling sites for each of the supply wells should be picked progressively further downstream from the Stratford STP.

Based on current drilling costs applied for three test holes in the area, about \$10,000 per well would be required just for test drilling. Additional costs for hydrogeologic consultants to analyze the test drilling data and make recommendations for subsequent work in the project would be needed.

Assuming that the test drilling is successful in locating sufficient quantities of good-quality water, the final design of the flow augmentation project can be undertaken.

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Water well records on file with the MOE as of September 1981.

APPENDIX A

Background Hydrogeologic Data for the
Upper Portion of the Avon River

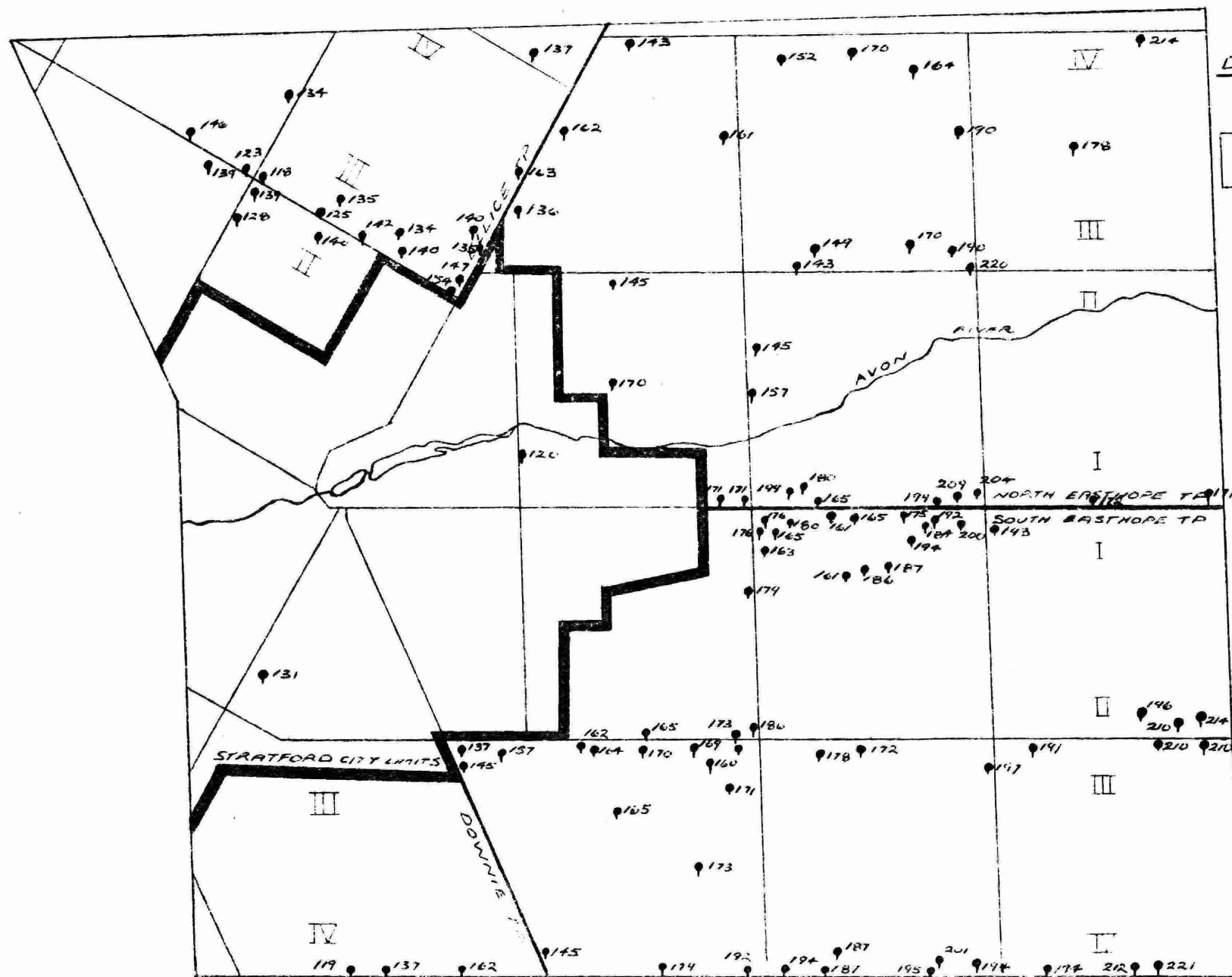
BEDROCK GEOLOGY

Legend:

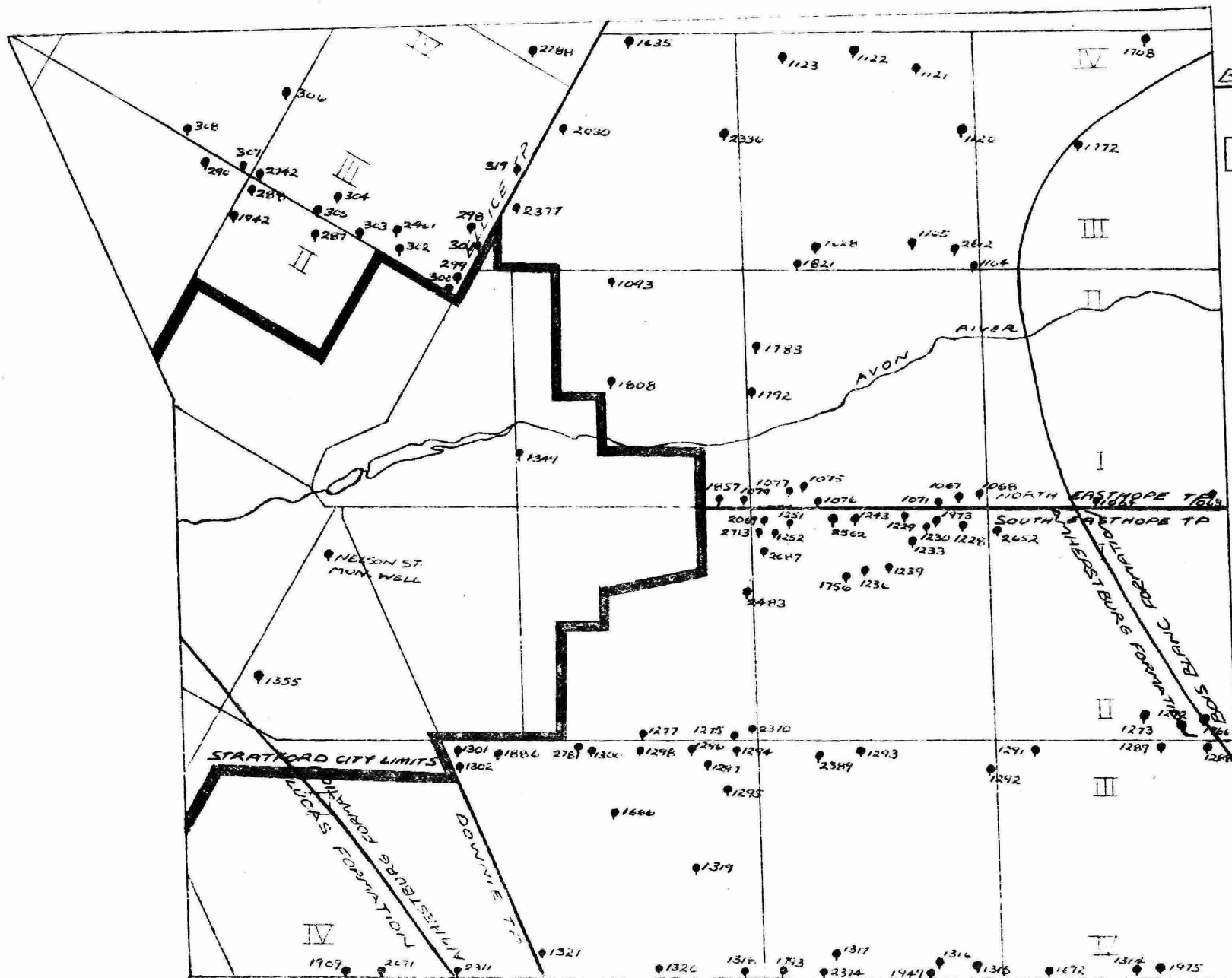
Lucas Formation: Anderson Member: brown limestone

Amhestburg Formation: Grey to dark brown limestone
and dolomite, locally cherty, bituminous and biostromal

Bois Blanc Formation: Grey dolomite, limestone and chert



Scale
0 2
miles

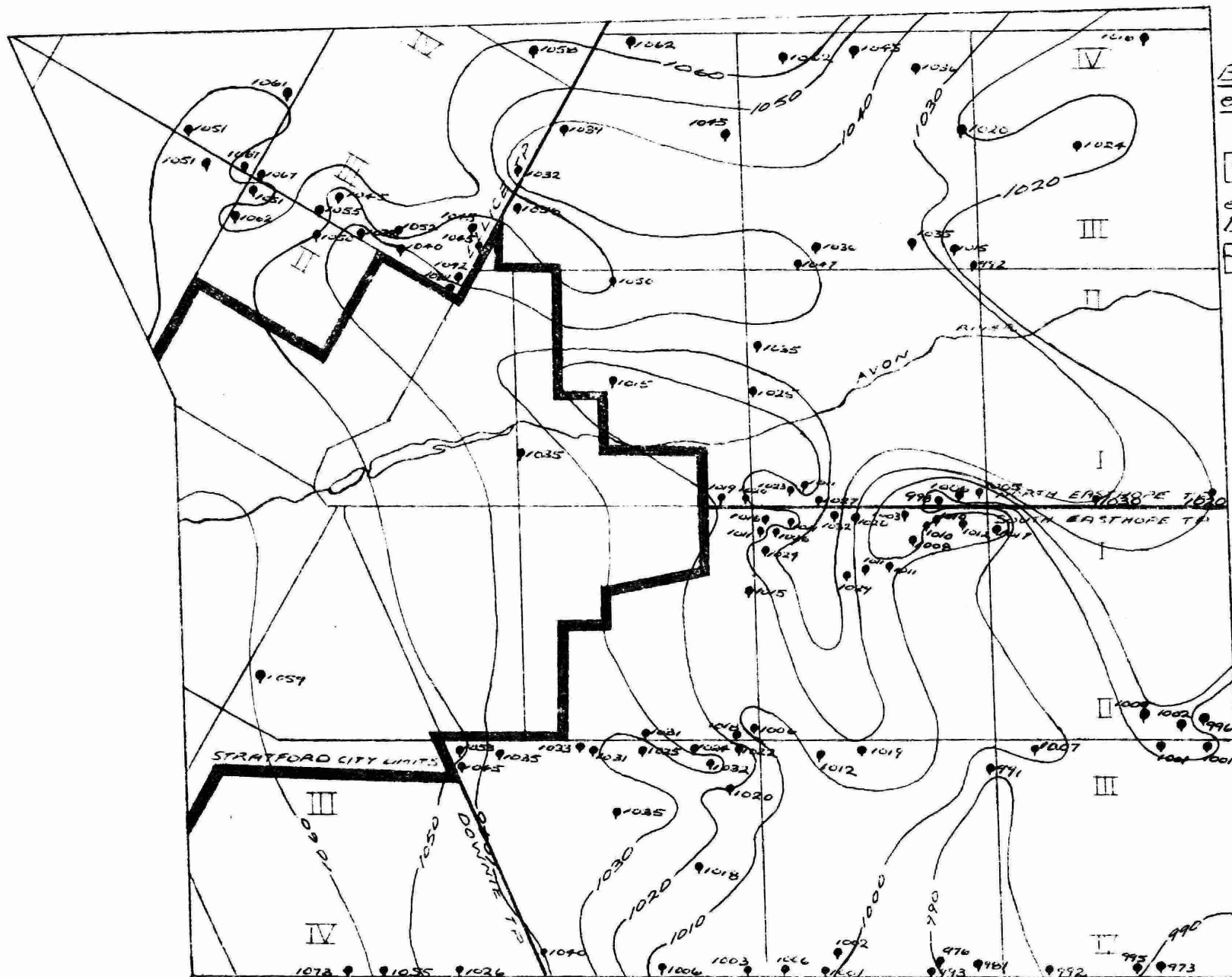


Bedrock geology and aquifers

● 308 well location and number

Scale

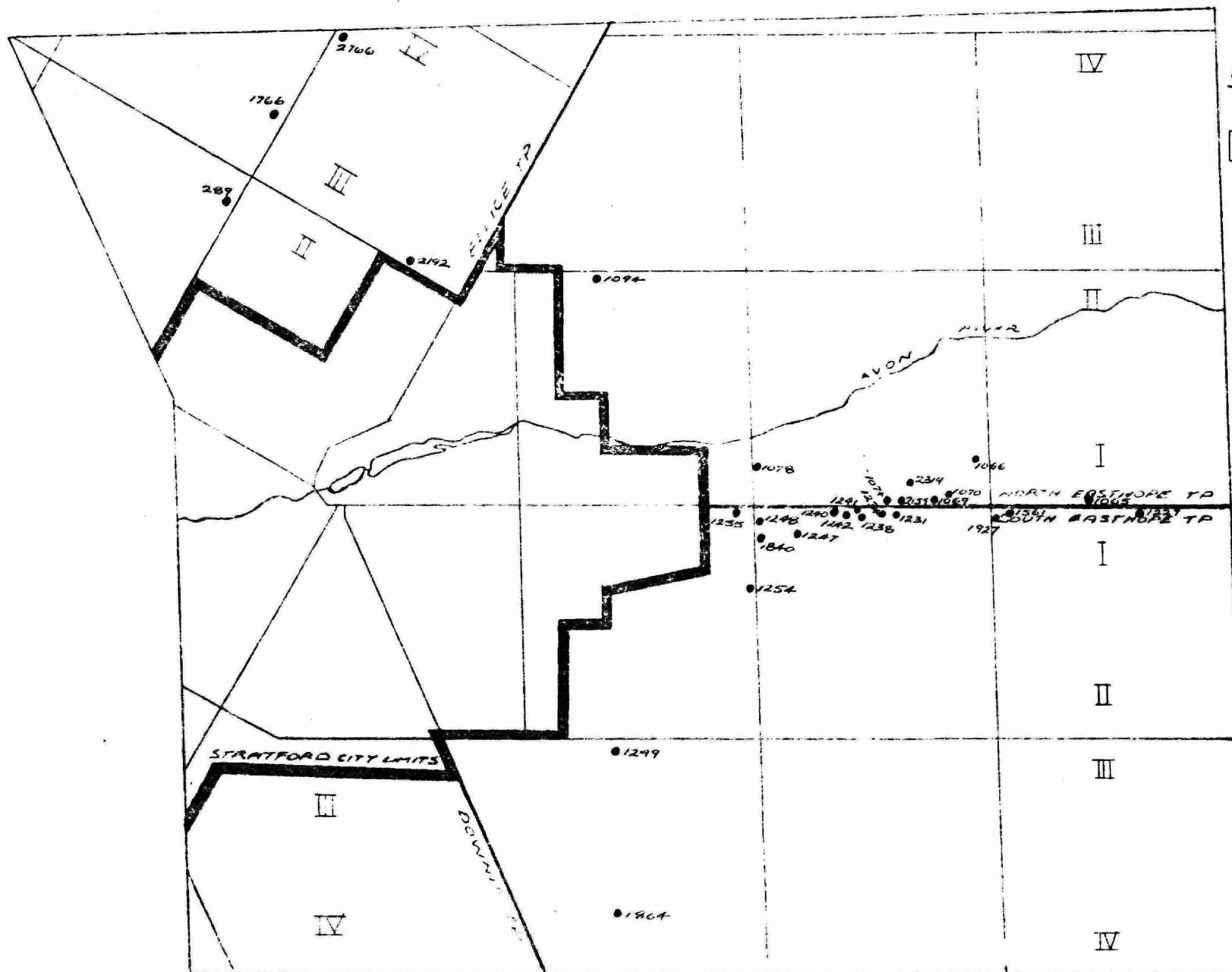
miles



Bedrock surface
elevation contours

• 1073 bedrock well
location and
elevation (feet) of
bedrock surface
- 1060 - elevation contour
(feet)

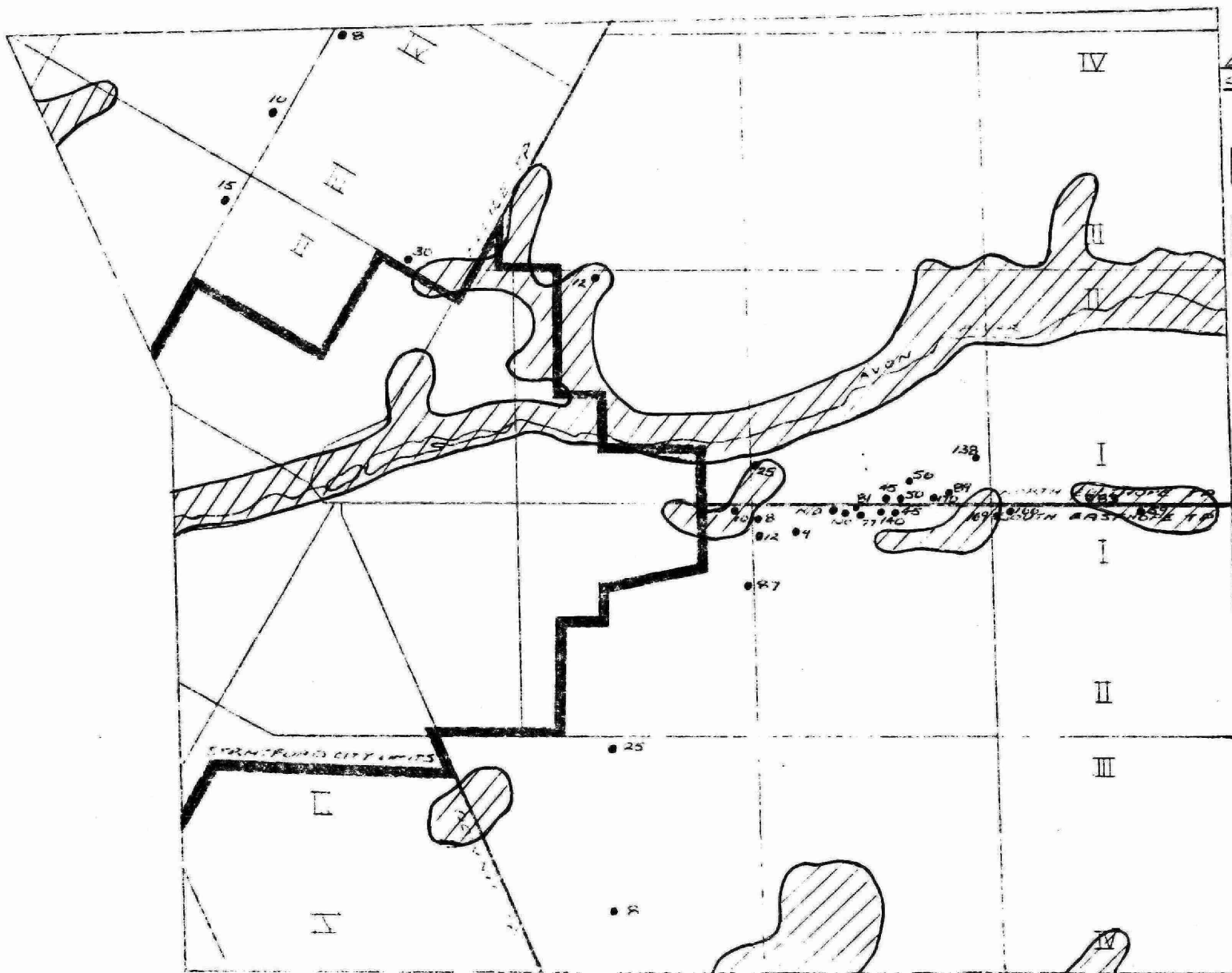
Scale
0 2
miles



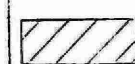
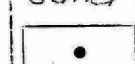
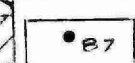
Overburden wells

• 287 well location and number

Scale
0 2
miles



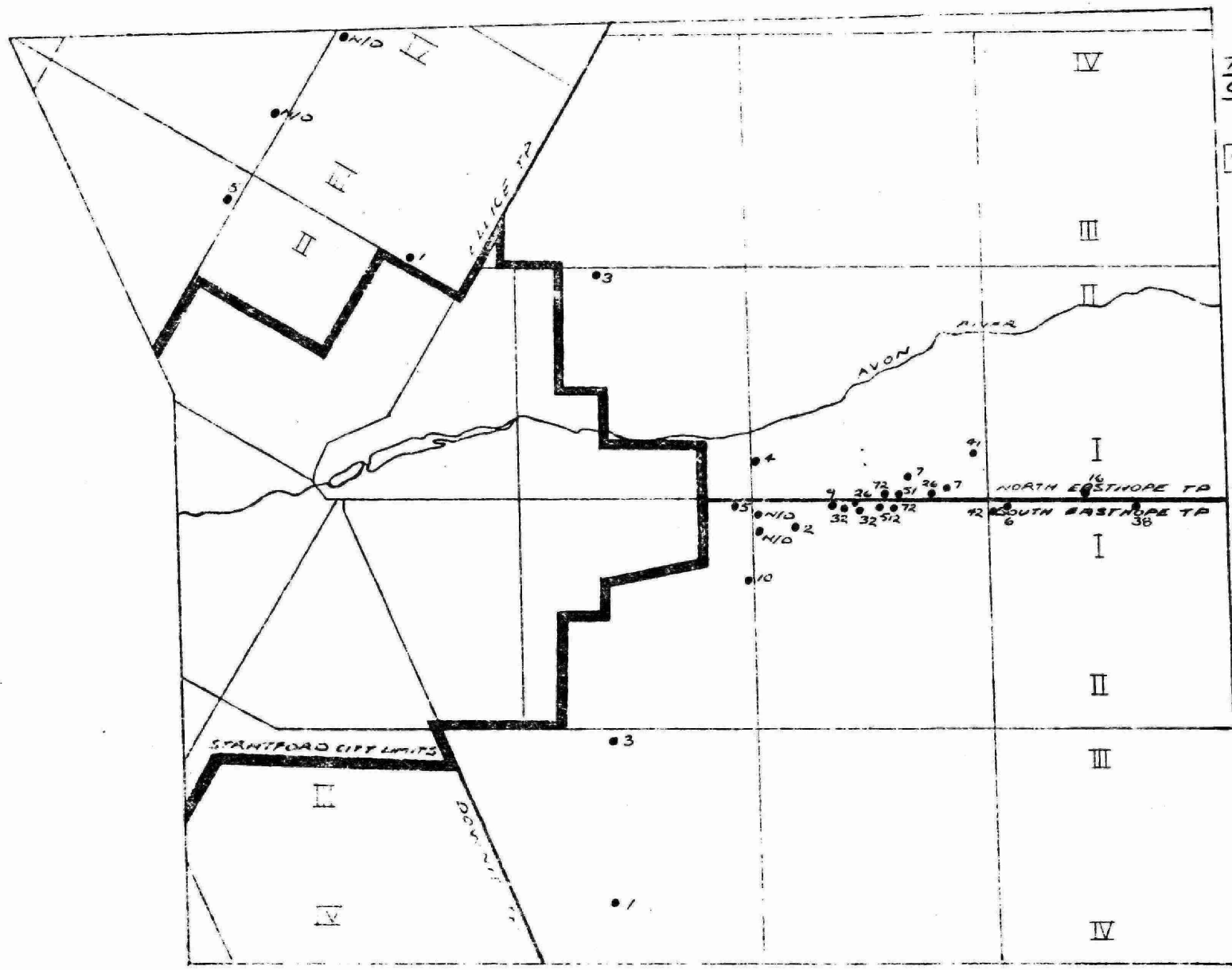
Extent of shallow overburden aquifers

-  extent of shallow aquifer: sand and/or gravel
-  overburden well location
-  depths to water found in overburden (feet)

Scale
0 2
miles

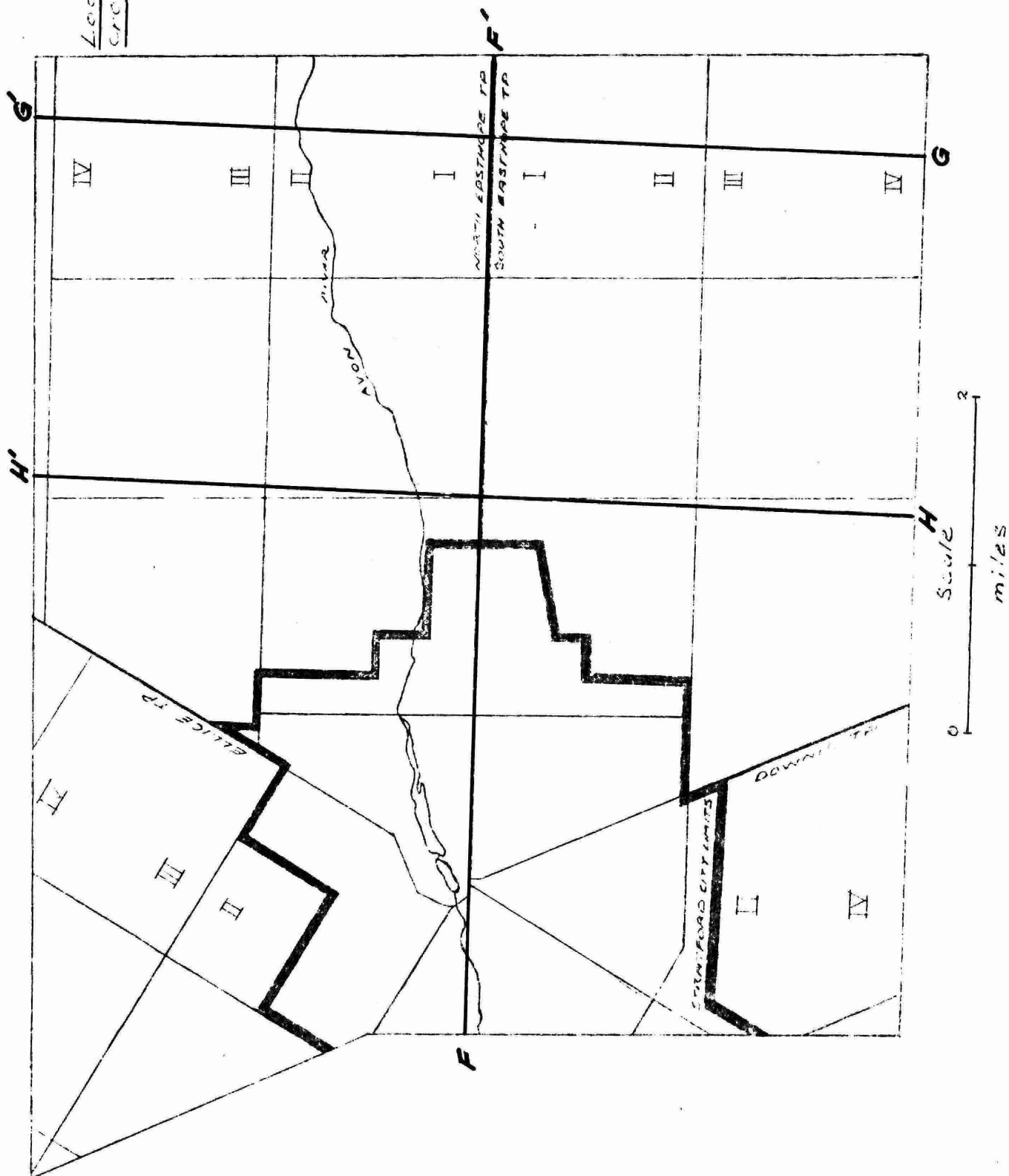
Theoretic yields of
overburden wells

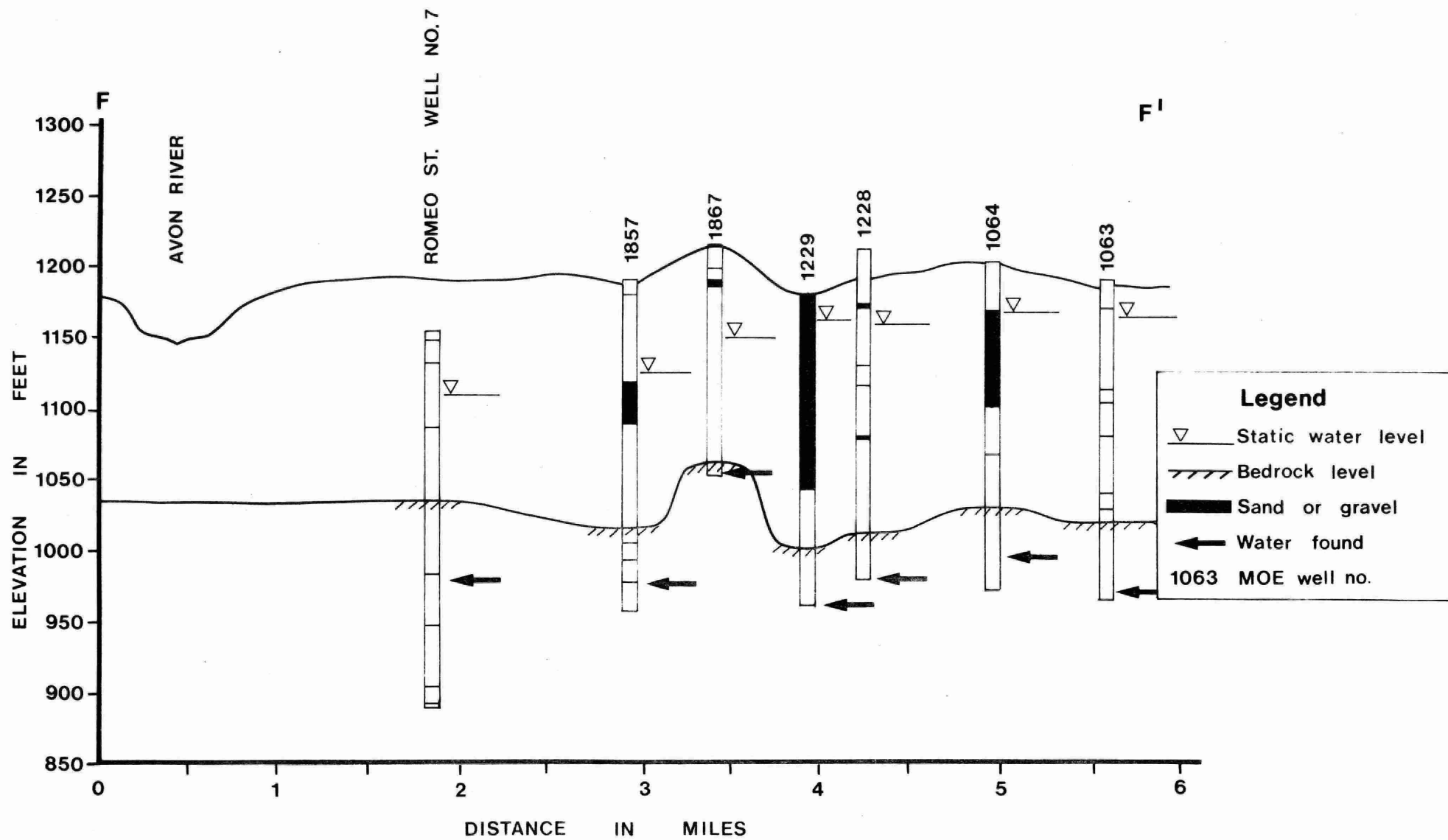
• 7 theoretic yield (g.p.m.)



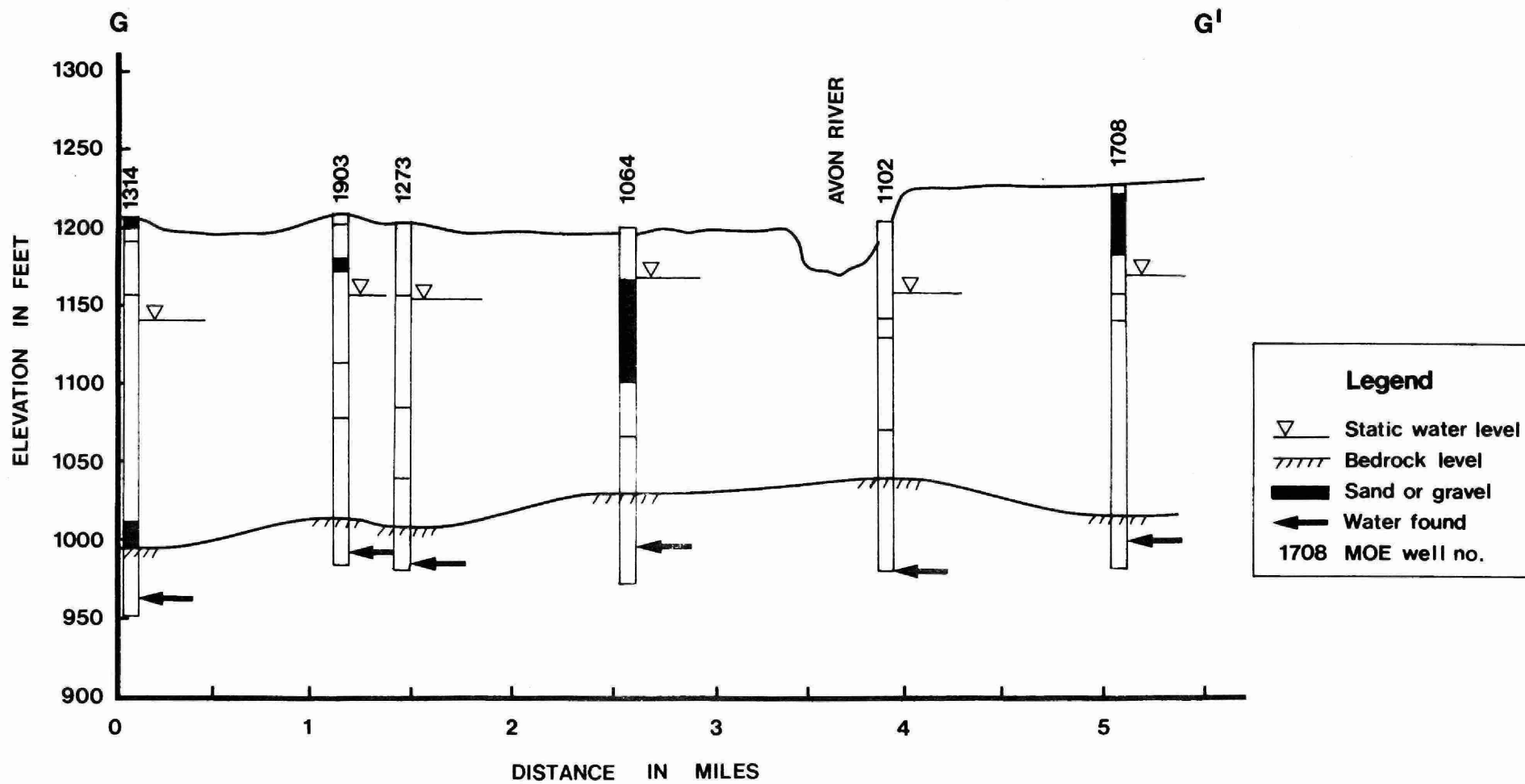
Scale
0 ————— 2
miles

Locations of geologic cross-sections

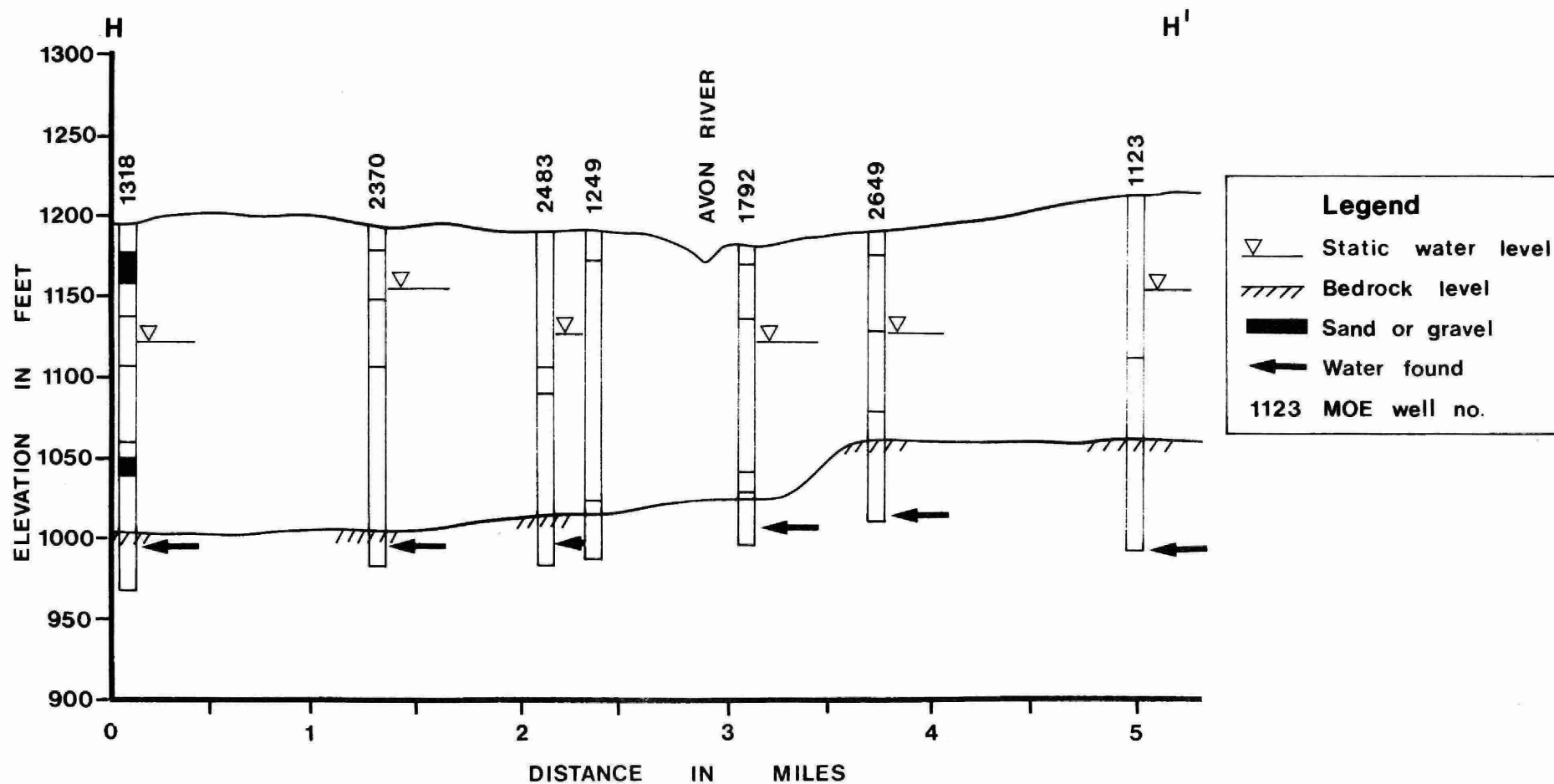




GEOLOGIC CROSS - SECTION F - F'



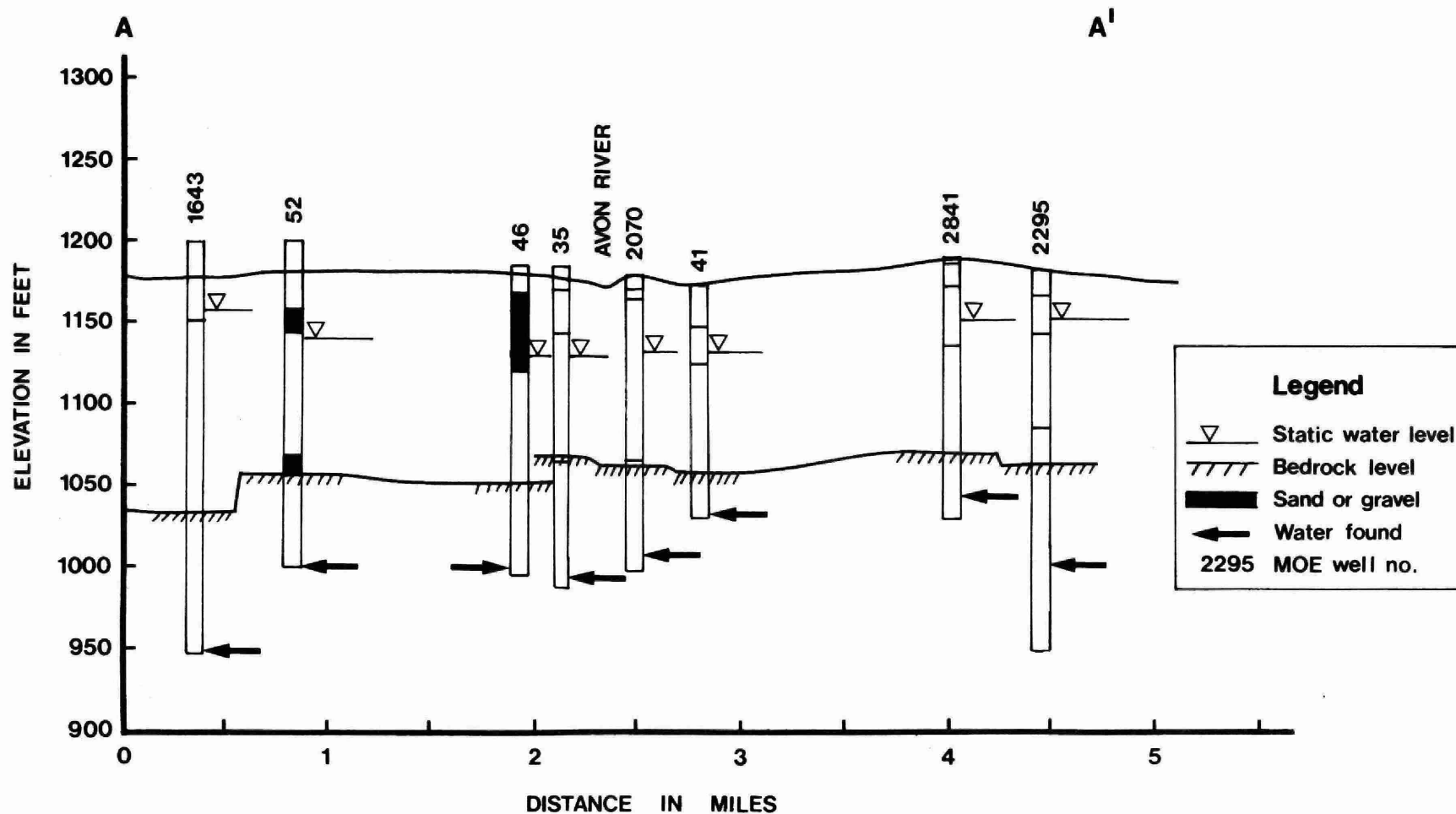
GEOLOGIC CROSS-SECTION G - G'



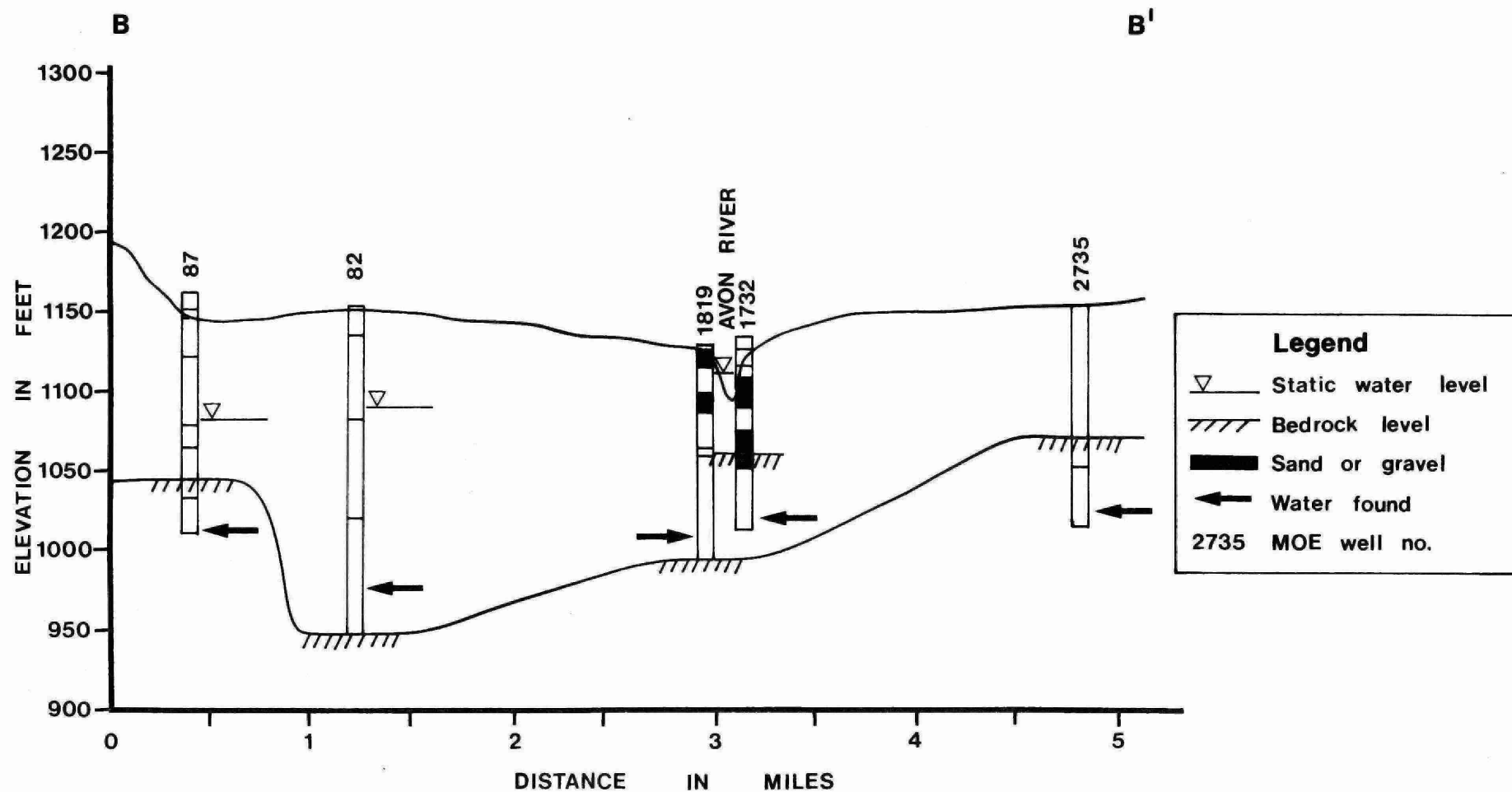
GEOLOGIC CROSS - SECTION H - H'

APPENDIX B

Geologic Cross-Sections

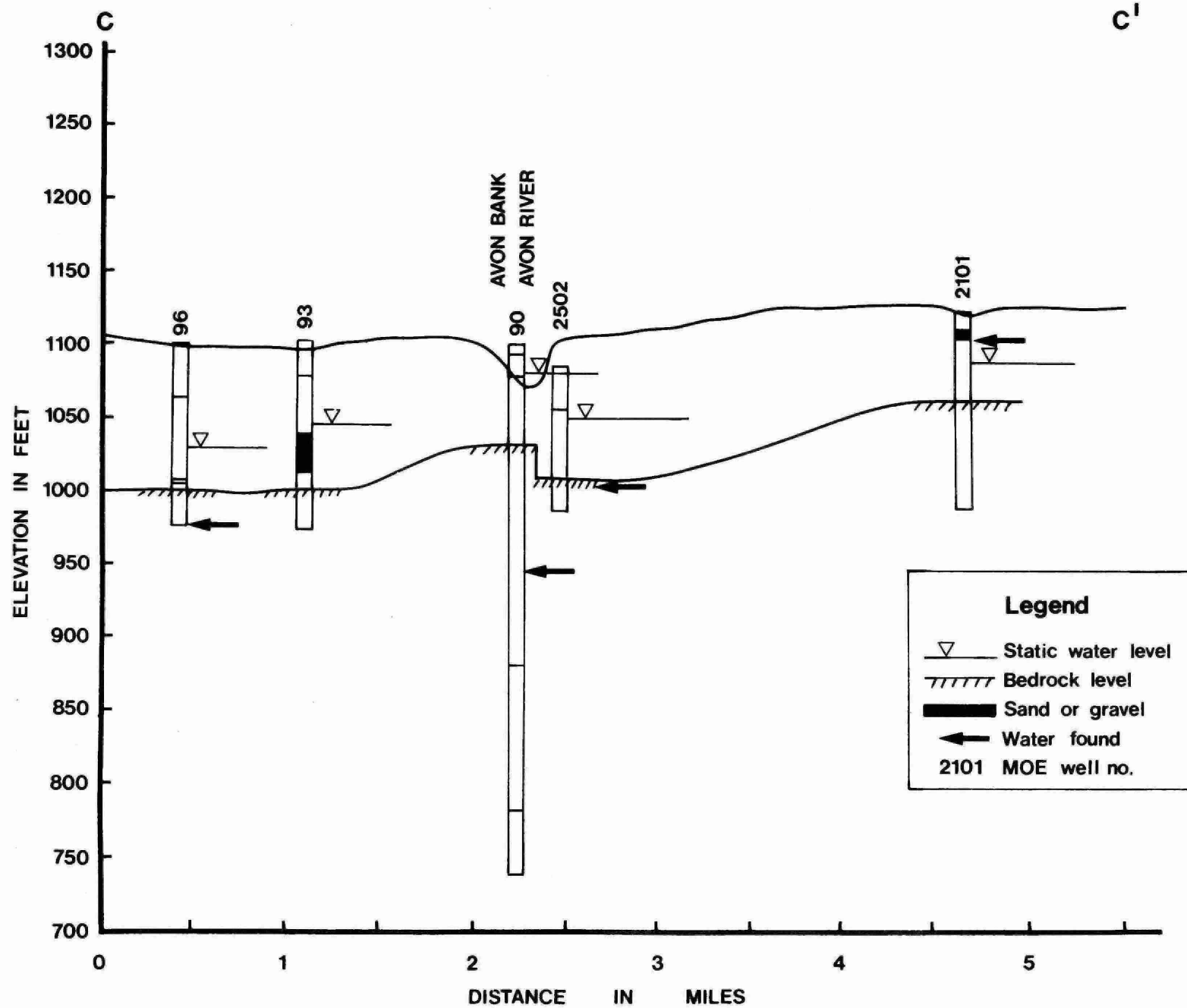


GEOLOGIC CROSS-SECTION A - A'

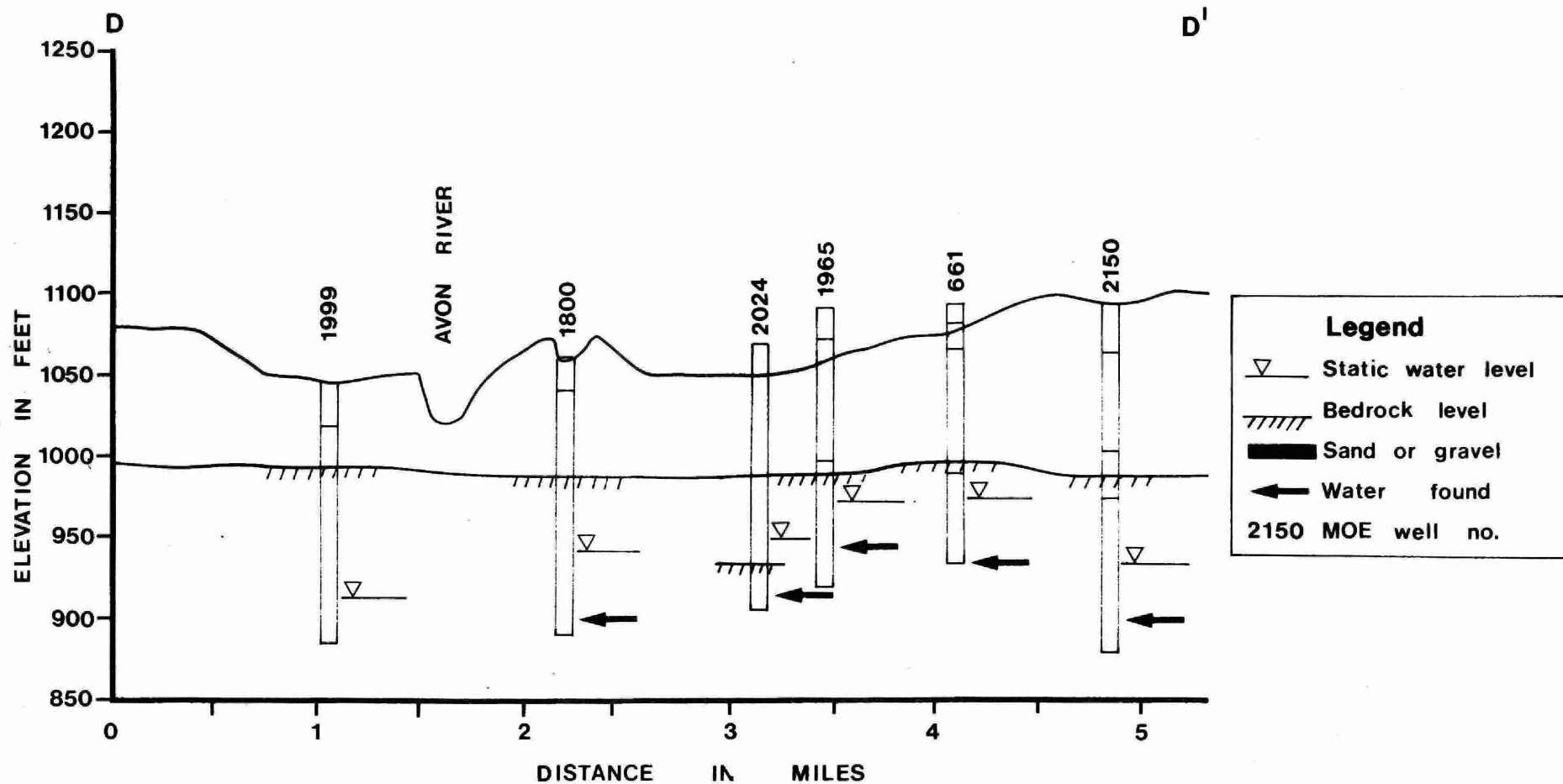


44

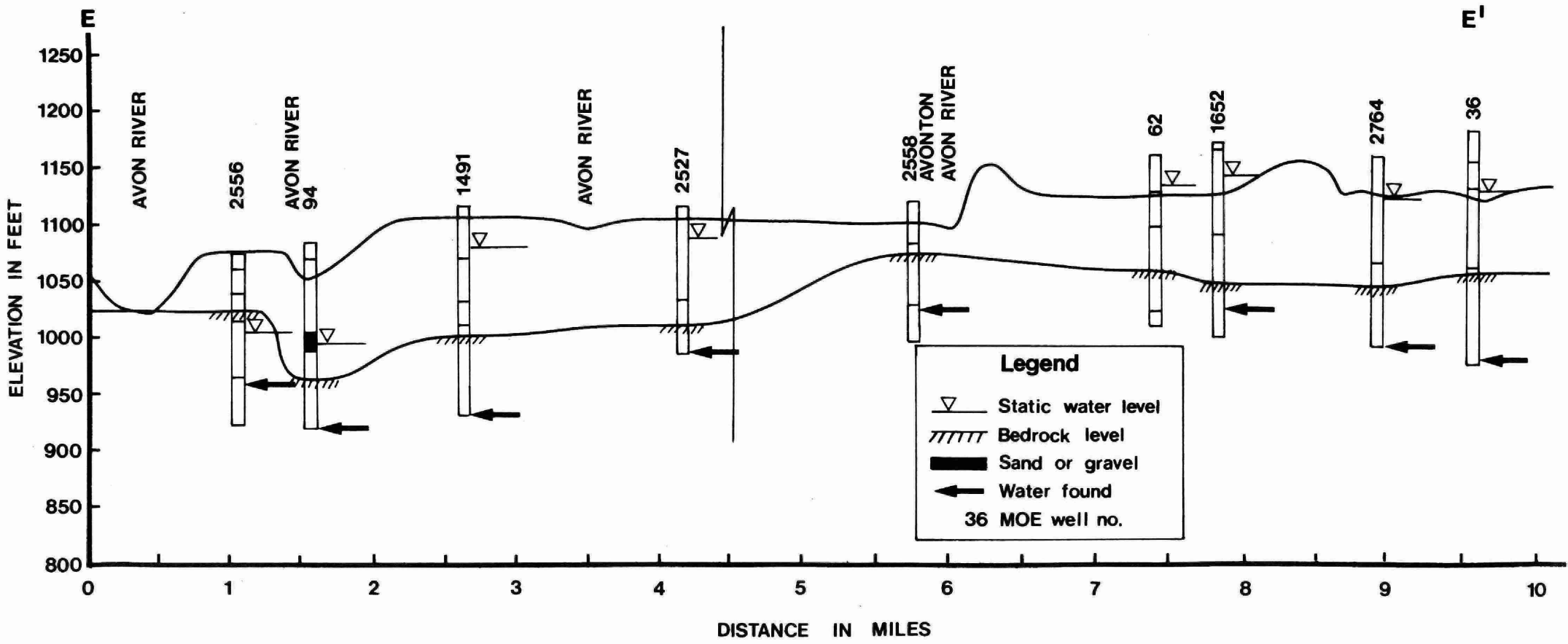
44



GEOLOGIC CROSS-SECTION C - C'



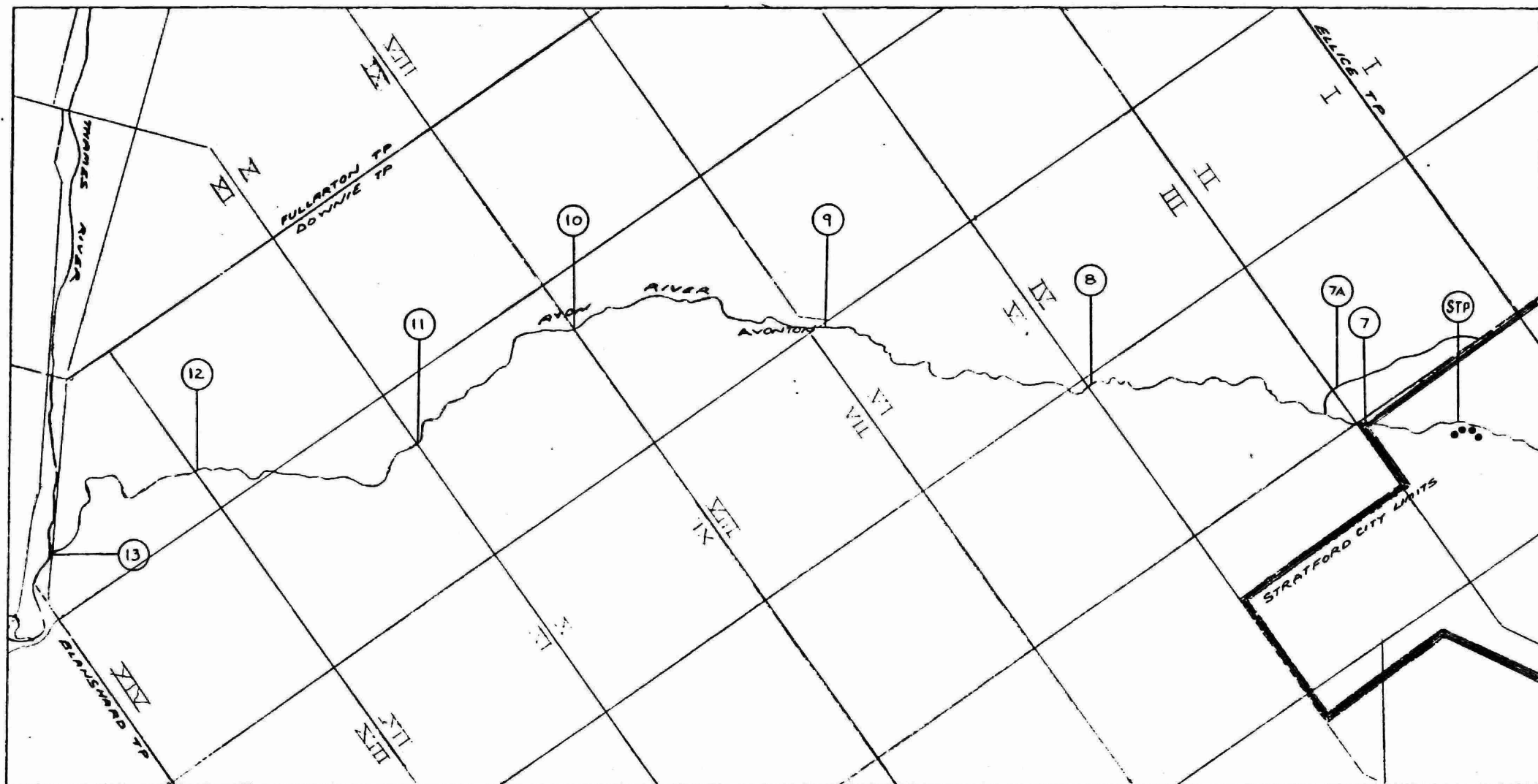
GEOLOGIC CROSS - SECTION D - D'



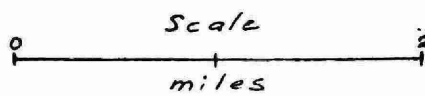
GEOLOGIC CROSS - SECTION ALONG AVON RIVER

APPENDIX C

Avon River Water Quality, 1981



Sampling locations, Avon River



- ⑦ sampling locations, surface water
- sewage treatment plant

Date 1981	DO mg/L	Temp °C	BOD ₅ (mg/L)	Bacteria/100 ml			Phosphorus		Nitrogens				SS	pH	Sp. Cond.	Cl
				Ps.a.	Fecal	Strep	Total	Sol	FA	Kjel	Nitrate	Nitrate				
Station STP																
Jan. 8	-	-	1.0	G4	2300	380	2.700	2.420	0.875	3.25	1.080	18.10	3.2	7.46	1850	260
Jan. 21	-	-	3.0	G4	9200	1500	0.820	0.490	3.300	0.18	1.380	11.00	1.2	7.52	1850	205
Feb. 12	-	-	2.3	12	6100	4400	0.540	0.360	2.600	3.55	0.335	7.80	2.7	7.53	1600	255
Feb. 17	9.4	8.0	2.9	G600	G150,000	G46,600	2.750	0.900	6.300	10.00	0.270	3.10	30.8	7.27	1490	252
Feb. 25	9.8	6.0	4.4	G4	89,000	21,000	0.600	0.290	2.700	3.85	3.220	5.20	1.7	7.78	1490	220
Mar. 4	9.6	7.5	1.2	*	100,000	10,000	0.520	0.320	6.100	6.80	0.570	5.10	4.8	7.63	1770	270
Mar. 19	9.3	7.0	14.6	264	240,000	25,000	0.850	0.360	6.050	7.00	1.080	10.20	9.6	7.45	2000	305
Mar. 31	-	-	13.2	G4	A60	440	0.700	0.360	4.000	5.10	2.580	3.80	10.3	7.42	1500	215
Apr. 14	6.6	10.0	21.6	C720	1,310,000	136,000	1.470	0.155	5.800	9.25	3.700	7.30	29.3	7.40	1170	165
Apr. 27	10.0	9.5	40.0	G4	1600	1,000	3.700	0.860	17.800	22.50	0.004	0.02	54.3	7.43	1640	210
May 25	-	-	6.0	-	-	-	.400	0.169	10.500	10.50	0.420	0.77	7.0	7.67	1620	202
June 9	8.9	16.5	5.7	G4	A10	110	2.255	0.089	5.450	6.70	0.630	9.50	3.0	7.54	1820	242
July 6	8.8	18.2	3.4	G4	8	4	0.052	0.009	0.310	1.26	0.091	15.40	0.1	7.42	1650	200
July 10	-	-	-	-	-	-	0.036	0.001	0.595	1.44	0.210	12.60	-	7.35	-	205
July 17	-	-	-	-	-	-	0.064	0.004	0.365	1.16	0.163	13.90	-	7.35	-	200
Aug. 4	-	-	3.0	G4	G4	12	.140	.061	2.600	3.18	.430	13.70	0.5	7.40	1820	280

- = Data Not Available

* Lab Accident

A = Approximately

L = Less Than

G = Greater Than

C = High Background Present

Date 1981	DO mg/L	Temp °C	BOD ₅ (mg/L)	Bacteria/100 ml			Phosphorus		Nitrogens				SS	pH	Sp. Cond.	Cl
				Ps.a.	Fecal	Strep	Total	Sol	FA	Kjel	Nitrate	Nitrate				
Station No. 7 (Downie, Con. 11 Lot 5 (Lorne St.))																
Jan. 8	-	0.0	1.3	G4	510	150	1.280	1.18	0.455	4.25	0.500	10.30	8.9	7.74	1250	138.0
Jan. 21	12.9	4.5	2.0	8	61,500	560	0.420	0.255	1.700	3.80	0.630	6.70	2.4	7.76	1270	112.0
Feb. 12	13.8	3.0	5.7	20	4300	380	0.310	0.165	1.200	1.30	0.270	4.50	35.0	7.60	1010	122.0
Feb. 17	11.8	3.5	10.8	C200	123,000	14,700	0.620	0.300	1.900	4.20	0.089	2.90	68.9	7.44	950	142.0
Feb. 25	11.6	1.0	2.2	G4	4400	4400	0.138	0.055	0.205	1.56	0.045	5.50	37.2	7.79	530	34.0
Mar. 4	11.1	3.0	0.4	12	A7000	A1,000	0.158	0.107	1.000	1.98	0.088	5.50	115.1	7.85	870	77.0
Mar. 19	13.9	6.0	2.2	24	1500	1,310	0.160	0.121	1.300	2.16	0.220	6.20	7.8	8.09	1070	108.0
Mar. 31	-	-	3.6	20	3600	1310	0.242	0.086	0.375	1.78	0.177	6.40	62.5	7.84	590	340.0
Apr. 14	9.6	10.0	11.2	248	G70,000	13,700	0.665	0.325	L1.000	3.60	0.980	0.71	60.4	7.51	700	82.5
Apr. 27	13.4	11.0	11.6	12	A200	G1500	-	-	4.700	7.75	0.196	-	27.1	-	-	-
May 5	-	-	5.8	-	-	-	0.330	0.055	3.350	5.30	0.191	2.50	9.4	7.92	-	66.0
May 25	-	-	3.6	-	-	-	0.130	0.049	1.900	3.16	0.186	2.60	8.9	8.03	825	58.5
June 8	7.8	17.5	-	G4	120	48	0.170	0.046	1.100	3.40	0.830	6.20	10.6	7.80	-	-
June 9	11.6	20.2	5.2	G4	720	160	0.150	0.035	1.400	2.78	0.960	5.20	9.8	7.85	1160	115.0
June 15	9.2	21.8	-	8	1250	260	0.146	0.038	1.420	2.62	0.495	5.50	7.0	7.89	-	-
June 24	7.0	19.5	-	G4	A2000	A300	0.092	0.031	0.340	1.32	0.320	9.18	8.7	7.85	-	-
July 6	13.4	23.4	2.2	G4	180	110	0.072	0.002	0.055	1.12	0.148	9.75	5.3	8.20	1080	100.0
July 10	-	-	-	-	-	-	0.050	0.002	0.155	1.22	0.390	6.00	-	8.20	-	95.5
Aug. 4	-	-	3.8	4	270	270	0.098	0.014	0.705	1.72	0.680	6.12	4.9	7.76	1200	148.0

- = Data Not Available

A = Approximately

L = Less Than

G = Greater Than

C = High Background Present

Date 1981	DO mg/L	Temp °C	BOD ₅ (mg/L)	Bacteria/100 ml			Phosphorus		Nitrogens				SS	pH	Sp. Cond.	Cl
				Ps.a.	Fecal	Strep	Total	Sol	FA	Kjel	Nitrate	Nitrate				
Station 7A (Avon Tributary) (Downie, Conn 111, lot 10)																
Jan. 8	-	0.0	0.5	G4	52	6600	0.042	0.019	0.205	1.02	0.030	6.80	7.4	7.82	830	45.5
Jan. 21	12.2	0.0	1.6	G4	76	112	0.146	0.100	0.235	0.62	0.039	5.90	3.8	7.78	1070	128.0
Feb. 17	11.8	0.5	1.5	G4	17,400	62,000	1.550	1.020	2.350	7.20	0.030	6.10	61.6	7.23	750	94.0
Feb. 25	11.3	1.0	2.4	G4	1000	23,000	0.134	0.070	0.115	1.34	0.064	8.20	11.6	7.77	510	28.5
Mar. 4	8.4	2.0	0.5	G4	30	80	0.038	0.025	0.060	0.82	0.019	8.90	15.9	7.93	710	54.5
Mar. 19	15.0	2.0	1.1	G4	36	88	0.038	0.018	0.035	0.88	0.030	8.70	9.1	8.07	730	58.0
Mar. 31	-	-	2.8	G4	60	440	0.072	0.022	0.020	1.02	0.033	9.00	14.7	8.03	590	30.5
Apr. 14	13.2	10.0	2.8	32	600	61,500	0.174	0.094	0.170	1.16	0.028	5.22	20.6	7.91	590	44.0
May 25	-	-	1.0	-	-	-	0.030	0.008	0.025	0.88	0.38	8.70	4.1	8.29	675	36.0
June 9	10.6	21.4	2.5	G4	1330	560	0.066	0.019	0.055	1.19	0.121	4.60	3.3	8.02	625	43.0
July 6	12.0	24.2	0.9	4	860	G1500	0.070	0.041	0.010	0.90	0.500	5.85	0.5	8.24	720	38.0
July 10	-	-	-	-	-	-	0.034	0.017	0.010	0.68	0.031	6.10	-	8.17	-	32.0
July 17	-	-	-	-	-	-	0.040	0.009	0.030	0.62	0.028	5.12	-	8.23	-	19.0
Aug. 4	-	-	1.3	G4	3500	4300	.326	.220	.020	0.80	0.028	4.10	2.1	8.08	875	33.0

- = Data Not Available

A = Approximately

L = Less Than

G = Greater Than

C = High Background Present

Date 1981	DO mg/L	Temp °C	BOD ₅ (mg/L)	Bacteria/100 ml			Phosphorus		Nitrogens				SS	pH	Sp. Cond.	Cl
				Ps.a.	Fecal	Strep	Total	Sol	FA	Kjel	Nitrate	Nitrate				
Station 8 (Downie, Con. III Lot 10)																
Jan. 8	-	0.0	1.1	G4	G10	156	0.880	0.880	0.715	1.40	0.290	7.40	3.8	7.76	1100	108.0
Jan. 21	11.6	0.0	3.1	G4	890	310	0.425	0.270	2.500	4.15	0.260	4.50	8.3	7.82	1180	101.0
Feb. 10	-	-	5.6	60	G35,500	9200	0.505	0.285	1.450	3.10	0.093	3.66	48.7	7.57	890	135.0
Feb. 25	11.4	1.0	2.4	G4	1900	5000	0.130	0.062	0.230	1.34	0.047	6.00	27.2	7.80	510	29.0
Mar. 4	11.4	2.5	1.2	4	A2000	A700	0.104	0.074	0.900	1.88	0.076	6.00	8.9	7.98	750	48.5
Mar. 19	-	-	4.3	G4	1900	1420	0.150	0.092	1.050	2.12	0.114	6.00	7.1	8.28	880	73.0
Mar. 31	-	-	3.4	32	1900	1040	0.224	0.083	0.295	1.62	0.200	6.90	55.8	7.85	610	3.8
Apr. 14	14.4	10.5	6.6	C20	6100	14,600	0.365	0.190	L1.900	2.30	0.030	4.80	44.3	7.87	620	61.5
May 5	-	-	5.0	-	-	-	0.170	0.500	1.800	3.20	0.430	4.20	7.3	8.00	-	61.0
May 25	-	-	4.4	-	-	-	0.094	0.034	0.850	2.04	0.310	4.20	6.0	8.22	760	46.0
June 9	17.5	22.7	4.1	G4	220	36	0.134	0.020	0.035	1.42	0.290	4.10	12.1	8.46	940	83.0
July 6	16.3	25.9	2.6	G4	260	60	0.080	0.005	0.015	1.22	0.185	7.60	8.6	8.43	910	84.0
July 10	-	-	-	-	-	-	0.054	0.013	0.030	0.86	0.310	6.20	-	8.18	-	140.0
July 17	-	-	-	-	-	-	0.148	0.002	0.025	1.80	0.270	7.20	-	8.27	-	162.0
Aug. 4	-	-	3.6	4	920	130	.078	G.001	.240	1.62	.270	5.13	10.5	8.24	1170	125.0

- = Data Not Available

A = Approximately

L = Less Than

G = Greater Than

C = High Background Present

Date 1981	DO mg/L	Temp °C	BOD ₅ (mg/L)	Bacteria/100 ml			Phosphorus		Nitrogens				SS	pH	Sp. Cond.	Cl
				Ps.a.	Fecal	Strep	Total	Sol	FA	Kjel	Nitrate	Nitrate				
Station 9 (Downie, Avonton)																
Jan. 8	-	0.0	0.7	G4	290	150	0.670	0.550	0.625	1.50	0.200	8.00	2.3	7.72	1150	120.0
Jan. 21	9.8	0.0	2.4	G4	G1500	310	0.485	0.410	2.400	3.70	0.210	5.80	3.3	7.76	1230	120.0
Feb. 25	12.0	0.0	2.2	G4	G1500	4000	0.130	0.060	0.190	1.32	0.051	6.30	26.2	7.84	490	26.0
Mar. 4	10.2	3.0	1.1	G4	2100	340	0.104	0.076	0.640	1.52	0.061	6.00	8.8	8.01	700	39.0
Mar. 19	-	-	1.2	G4	A30	A10	0.096	0.063	0.660	1.46	0.085	5.76	3.3	8.27	930	83.5
Mar. 31	-	-	2.6	16	140	920	0.228	0.088	0.340	1.76	0.166	6.90	51.3	7.86	590	33.5
Apr. 14	9.8	9.8	8.1	C108	G1500	G1500	0.380	0.215	71.000	2.45	0.170	4.13	51.1	7.85	590	53.0
May 25	-	-	3.1	-	-	-	0.098	0.028	0.250	1.32	0.163	4.20	8.6	8.50	690	39.0
June 9	15.5	23.2	4.7	G4	530	32	0.110	0.024	0.755	1.86	0.600	4.40	7.6	8.29	1170	130.0
July 6	14.4	27.3	2.4	G4	100	92	0.082	0.009	0.015	1.22	0.158	6.70	5.4	8.46	970	99.5
July 10	-	-	-	-	-	-	0.102	0.009	0.015	1.18	0.078	5.20	-	8.22	-	100.0
July 17	-	-	-	-	-	-	0.080	0.017	0.035	0.98	0.062	5.40	-	8.23	-	132.0
Aug. 4	-	-	1.6	4	200	116	.080	.023	.050	.92	.028	4.27	3.9	8.40	1070	120.0

- = Data Not Available

L = Less Than

A = Approximately

G = Greater Than

C = High Background Present

Date 1981	DO mg/L	Temp °C	BOD ₅ (mg/L)	Bacteria/100 ml			Phosphorus		Nitrogens				SS	pH	Sp. Cond.	Cl
				Ps.a.	Fecal	Strep	Total	Sol	FA	Kjel	Nitrate	Nitrate				
Station 10 (Downie, County Rd. 17, Con. , Lot 19)																
Jan. 8	-	0.0	0.4	G4	A80	A20	0.202	0.172	0.380	1.02	0.096	7.90	2.6	7.83	1120	108.0
Jan. 21	9.8	0.0	1.1	G4	408	160	0.500	0.440	0.975	1.44	0.171	6.80	2.8	7.75	1180	110.0
Feb. 25	12.4	0.0	2.5	4	G1500	3600	0.142	0.062	0.210	1.36	0.051	6.20	25.7	7.84	476	22.5
Mar. 4	13.2	2.0	1.3	G4	2000	260	0.088	0.063	0.650	1.46	0.051	6.20	8.3	8.03	700	40.5
Mar. 19	-	-	1.1	G4	A40	G10	0.084	0.065	0.795	1.54	0.088	5.99	3.6	8.23	1030	115.0
Mar. 31	-	-	3.5	12	920	432	0.220	0.085	0.305	1.62	0.137	6.90	51.7	7.92	570	30.5
Apr. 14	11.6	9.5	6.8	128	G1500	1180	0.345	0.195	71.000	2.35	0.172	3.83	44.6	7.83	590	50.5
May 5	-	-	2.6	-	-	-	0.160	0.053	82.000	1.84	0.320	4.50	12.0	8.28	-	65.5
May 25	-	-	2.8	-	-	-	0.124	0.025	0.120	1.32	0.135	4.60	5.6	8.55	685	39.5
June 9	24.1	14.2	2.4	G4	420	16	0.098	0.038	0.050	1.12	0.240	5.50	5.8	8.56	1120	122.0
July 6	28.5	13.7	2.5	4	270	40	0.106	0.021	0.035	1.30	0.076	5.60	7.6	8.46	900	84.5
July 10	-	-	-	-	-	-	0.114	0.041	0.195	1.26	0.085	3.90	-	7.92	-	129.0
July 17	-	-	-	-	-	-	0.104	0.023	0.080	1.14	0.100	4.80	-	8.02	-	145.0
Aug 4	-	-	1.5	G4	180	112	.092	.020	.035	1.02	.035	3.07	10.4	8.40	1020	125.0

- = Data Not Available

A = Approximately

L = Less Than

G = Greater Than

C = High Background Present

Date 1981	DO mg/L	Temp °C	BOD ₅ (mg/L)	Bacteria/100 ml			Phosphorus		Nitrogens				SS	pH	Sp. Cond.	Cl
				Ps.a.	Fecal	Strep	Total	Sol	FA	Kjel	Nitrate	Nitrate				
Station 11 (Downie, Avon Bank, Con. 10 Lot 19)																
Jan. 8	-	0.0	0.5	G4	52	36	0.188	0.162	0.520	1.26	0.071	6.70	2.1	7.73	1050	88.0
Jan. 21	9.0	-0.5	1.2	G4	132	68	0.450	0.400	0.735	1.29	0.134	6.90	8.4	7.75	1160	108.0
Feb. 25	12.6	0.0	2.4	4	1200	1700	0.134	0.062	0.195	1.34	0.050	6.40	24.0	7.86	772	20.5
Mar. 4	12.2	2.0	0.7	G4	1300	220	0.086	0.063	0.655	1.50	0.042	6.30	5.2	8.05	690	40.0
Mar. 19	-	-	1.2	G4	A20	G10	0.082	0.059	0.770	1.46	0.091	2.86	5.3	8.22	1110	148.0
Mar. 31	-	-	3.3	16	830	348	0.238	0.073	0.280	1.72	0.132	6.90	47.2	7.96	570	29.5
Apr. 14	10.8	10.0	5.4	80	G1500	G1500	0.300	0.184	G1.000	2.15	0.141	3.99	36.6	7.88	630	49.0
May 25	-	-	2.4	-	-	-	0.084	0.024	0.085	1.12	0.130	5.10	4.5	8.61	690	42.0
June 9	24.2	13.4	2.4	G4	200	36	0.098	0.048	0.045	1.20	0.097	4.20	7.1	8.61	1020	104.0
July 6	29.0	12.3	2.4	4	300	196	0.104	0.030	0.030	1.24	0.056	5.30	7.9	8.52	860	80.0
July 10	-	-	-	-	-	-	0.106	0.045	0.070	1.26	0.055	3.70	-	8.06	-	180.0
July 17	-	-	-	-	-	-	0.105	0.028	0.055	1.12	0.046	3.65	-	8.21	-	128.0
Aug. 4	-	-	1.5	G4	310	A80	0.640	0.015	0.035	0.92	0.027	2.67	5.7	8.59	1040	122.0

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Date 1981	DO mg/L	Temp °C	BOD ₅ (mg/L)	Bacteria/100 ml			Phosphorus		Nitrogens				SS	pH	Sp. Cond.	Cl
				Ps.a.	Fecal	Strep	Total	Sol	FA	Kjel	Nitrate	Nitrate				
Station 12 (Downie, Con. , Lot 20)																
Jan. 8	-	0.0	0.5	G4	32	144	0.180	0.163	0.625	1.22	0.069	6.80	2.0	7.68	1070	90.0
Jan. 21	9.8	0.0	1.3	G4	124	72	0.375	0.350	0.915	1.37	0.082	6.37	1.1	7.73	1140	108.0
Feb. 25	12.6	0.0	2.4	4	1200	2100	0.136	0.062	0.185	1.38	0.048	6.60	25.0	7.86	466	20.0
Mar. 4	10.4	2.0	1.3	G4	1300	230	0.086	0.060	0.570	1.36	0.043	6.90	5.1	8.06	670	38.5
Mar. 19	-	-	1.4	G4	G10	A20	0.074	0.051	0.635	1.32	0.092	6.06	3.7	8.23	1110	152.0
Mar. 31	-	-	2.7	24	870	620	0.186	0.07	0.225	1.26	0.115	7.40	35.4	8.05	570	27.5
Apr. 14	10.8	9.0	5.8	32	G1500	G1500	0.315	0.185	L1.000	2.35	0.149	5.00	33.7	7.98	670	50.0
May 25	-	-	2.5	-	-	-	0.066	0.019	0.050	1.02	0.121	5.30	5.4	8.53	675	42.5
June 9	25.1	15.8	1.8	G4	48	40	0.072	0.037	0.025	1.00	0.063	3.30	6.0	8.72	955	97.5
July 6	29.5	13.8	2.2	G4	350	G272	0.108	0.033	0.030	1.22	0.043	5.20	10.4	8.67	850	82.0
July 10	-	-	-	-	-	-	0.148	0.052	0.040	1.28	0.034	3.50	-	8.28	-	180.0
July 17	-	-	-	-	-	-	0.098	0.029	0.045	1.20	0.028	2.77	-	8.49	-	125.0
Aug. 4	-	-	1.2	G	180	140	0.058	0.008	0.940	0.02	2.130	0.06	10.2	8.76	980	112.0

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Date 1981	DO mg/L	Temp °C	BOD ₅ (mg/L)	Bacteria/100 ml			Phosphorus		Nitrogens				SS	pH	Sp. Cond.	Cl
				Ps.a.	Fecal	Strep	Total	Sol	FA	Kjel	Nitrate	Nitrate				
Station 13 (Mouth of Avon River)																
Jan. 8	-	0.0	0.5	G4	20	40	0.178	0.161	0.720	1.42	0.064	7.40	0.7	7.71	1130	112.0
Jan. 21	9.8	0.0	1.0	G4	136	20	0.335	0.310	1.280	1.67	0.033	5.92	1.1	7.68	1140	100.0
Feb. 12	11.8	1.3	3.6	12	G600	G600	0.325	0.230	1.400	2.05	0.047	3.80	7.2	7.61	1130	210.0
Feb. 17	11.8	2.0	4.6	16	G19,500	10,300	0.360	0.225	1.700	3.10	0.040	3.96	36.0	7.56	970	155.0
Feb. 25	12.6	0.0	2.1	8	1400	4600	0.138	0.065	0.175	1.36	0.047	7.10	23.6	7.92	464	20.0
Mar. 4	12.2	2.0	0.6	G4	1700	250	0.082	0.060	0.565	1.42	0.042	6.90	5.8	8.11	690	39.5
Mar. 19	-	-	1.1	G4	G10	A20	0.068	0.049	0.475	1.22	0.085	6.16	2.9	8.33	990	110.0
Mar. 31	-	-	3.3	8	400	370	0.182	0.067	0.200	1.54	0.110	7.10	41.3	8.11	550	27.5
Apr. 14	11.6	10.0	6.6	52	G1500	1360	0.355	0.205	L1.000	3.30	0.195	6.00	33.7	8.01	780	67.5
May 5	-	-	1.4	-	-	-	0.050	0.012	0.035	0.80	0.182	5.00	3.0	8.56	-	66.0
May 25	-	-	2.1	-	-	-	0.054	0.009	0.015	0.96	0.103	5.30	5.7	8.47	655	44.0
June 1	-	-	-	-	-	-	0.046	0.015	0.035	0.85	0.001	3.90	-	8.61	880	-
June 8	20.0	15.0	-	G4	104	24	0.056	0.006	0.020	1.00	0.017	1.83	6.8	8.71	-	-
June 9	24.9	14.4	1.9	G4	112	64	0.064	0.013	0.020	1.06	0.028	2.50	4.7	8.77	915	97.5
June 15	28.5	11.5	-	G4	264	128	0.130	0.057	0.065	1.12	0.060	1.69	8.5	8.49	-	-
June 24	18.2	11.4	-	G4	1070	240	0.124	0.038	0.085	1.22	0.159	9.90	22.4	8.24	-	-
July 6	30.7	11.9	1.8	G4	204	248	0.106	0.026	0.025	1.44	0.034	4.80	9.6	8.66	880	92.0
July 17	-	-	-	-	-	-	0.080	0.019	0.040	1.14	0.019	2.33	-	8.41	-	148.0
Aug. 4	-	-	1.5	G4	690	1400	0.086	0.018	0.045	1.00	0.007	1.23	9.5	8.94	875	112.0

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APPENDIX D

Addendum on
Flow Augmentation Requirements

A critical parameter for stream water quality control is phosphorus due to the eutrophication problem below the City of Stratford. Luxuriant plant growths have been observed in areas of the stream above Stratford where total phosphorus concentrations average about .05 to .06 mg/l in the summer, while downstream summer concentrations average about .1 mg/l (personnal communication, M. Fortin). Based on these values, a target concentration of less than .05 mg/l total phosphorus might be assumed. The mean 1980 summer baseflow was $.35 \text{ m}^3 \text{ sec}^{-1}$ at station 10 (personnal communication, M. Fortin). With a ground-water concentration of .025 mg/l, the augmentation requirement with indicated base flow would be $.7 \text{ m}^3 \text{ sec}^{-1}$, or 9000 gpm.

While there are individual Stratford city wells yielding up to 1000 gpm in the study area, it is highly unlikely that a sufficient number of such high-yielding wells could be developed in close proximity to the river below Stratford. Consequently, augmentation to this level does not appear to be feasible.

STRATFORD-AVON RIVER ENVIRONMENTAL MANAGEMENT PROJECT
LIST OF TECHNICAL REPORTS

- S-1 Impact of Stratford City Impoundments on Water Quality in the Avon River
- S-2 Physical Characteristics of the Avon River
- S-3 Water Quality Monitoring of the Avon River - 1980, 1981
- S-4 Experimental Efforts to Inject Pure Oxygen into the Avon River
- S-5 Experimental Efforts to Aerate the Avon River with Small Instream Dams
- S-6 Growth of Aquatic Plants in the Avon River
- S-7 Alternative Methods of Reducing Aquatic Plant Growth in the Avon River
- S-8 Dispersion of the Stratford Sewage Treatment Plant Effluent into the Avon River
- S-9 Avon River Instream Water Quality Modelling
- S-10 Fisheries of the Avon River
- S-11 Comparison of Avon River Water Quality During Wet and Dry Weather Conditions
- S-12 Phosphorus Bioavailability of the Avon River
- S-13 A Feasibility Study for Augmenting Avon River Flow by Ground Water
- S-14 Experiments to Control Aquatic Plant Growth by Shading
- S-15 Design of an Arboreal Shade Project to Control Aquatic Plant Growth

- U-1 Urban Pollution Control Strategy for Stratford, Ontario - An Overview
- U-2 Inflow/Infiltration Isolation Analysis
- U-3 Characterization of Urban Dry Weather Loadings
- U-4 Advanced Phosphorus Control at the Stratford WPCP
- U-5 Municipal Experience in Inflow Control Through Removal of Household Roof Leaders
- U-6 Analysis and Control of Wet Weather Sanitary Flows
- U-7 Characterization and Control of Urban Runoff
- U-8 Analysis of Disinfection Alternatives

- R-1 Agricultural Impacts on the Avon River - An Overview
- R-2 Earth Berms and Drop Inlet Structures
- R-3 Demonstration of Improved Livestock and Manure Management Techniques in a Swine operation
- R-4 Identification of Priority Management Areas in the Avon River
- R-5 Occurrence and Control of Soil Erosion and Fluvial Sedimentation in Selected Basins of the Thames River Watershed
- R-6 Open Drain Improvement
- R-7 Grassed Waterway Demonstration Projects
- R-8 The Controlled Access of Livestock to Open Water Courses
- R-9 Physical Characteristics and Land Uses of the Avon River Drainage Basin
- R-10 Stripcropping Demonstration Project
- R-11 Water Quality Monitoring of Agricultural Diffuse Sources
- R-12 Comparative Tillage Trials
- R-13 Sediment Basin Demonstration Project
- R-14 Evaluation of Tillage Demonstration Using Sediment Traps
- R-15 Statistical Modelling of Instream Phosphorus
- R-16 Gully Erosion Control Demonstration Project
- R-17 Institutional Framework for the Control of Diffuse Agricultural Sources of Water Pollution
- R-18 Cropping-Income Impacts of Management Measures to Control Soil Loss
- R-19 An Intensive Water Quality Survey of Stream Cattle Access Sites



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